

Sean A. Kingsley



Fishing and Shipwreck Heritage

Marine Archaeology's Greatest Threat?



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To Kurt Raveh

*Perfect memories of the good old days,
diving, discoveries and drinking coffee
with wise fishermen along the coast*

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Preface

*Roll on, thou deep and dark blue Ocean – roll!
Ten thousand fleets over thee in vain;
Man marks the earth with ruin – his control
Stops with the shore.*

Lord Byron, *Childe Harold's Pilgrimage* (1818)

On a flat sea in May 2008, the *Odyssey Explorer* research ship was on station over a seventeenth-century wreck in the Western Approaches to the English Channel. No land could be spied, just a wilderness of endless water. The Florida-based commercial archaeology team Odyssey Marine Exploration had invited me to help assess some post-medieval shipwrecks sunk at depth beneath the Narrow Seas. Before sending a remotely operated vehicle down 110 metres for annual monitoring of a site codenamed 35F, the project manager, Tom Dettweiler, unrolled a printout of a side-scan sonar image taken in 2005.

The entire seabed was raked with parallel lines running straight through the shipwreck (see Fig. 15). A fishing boat towing eighteen scallop dredges on each side had ploughed directly through rare underwater cultural heritage and the team was concerned about the site's condition three years later. Beneath the waves the scene was one of devastation, even for these unforgiving waters. Only a small remnant of the exotic cargo of elephant tusks and copper *manilla* bracelets, used to barter for goods in West Africa, survived. Fishing cable and net were snagged across the site. Scallop dredge teeth had sliced deeply through the surfaces of some iron cannon. Twelve others had been chaotically dragged in trawl nets up to 300 metres away from the wreck mound. Bottom fishing had transformed what the team and I later interpreted as probably the only late

seventeenth-century English Royal Africa Company merchant vessel found off Britain into a virtual dead zone (Cunningham Dobson and Kingsley 2011).

What terrible luck, I recalled at the time, that of all the water in the ocean, scallop dredgers and trawlers had happened to crash through one of Britain's most important examples of post-medieval sunken heritage. By the end of the large-scale Odyssey survey covering over 4,725 square nautical miles of international waters off the southwest United Kingdom, I realised that luck had nothing to do with it. Some 112 or 42 per cent of the 267 wrecks identified turned out to be associated with some form of fishing impact. These ranged from the superficially benign dumping of broken gear on dangerous snags best avoided by fishing boats to the severe damage inflicted on the West Africa trader's hull and cargo.

Naively, I assumed this first quantified fishing threat to the British Isles' sunken past was a serious concern, which needed sharing with the outside world and addressing swiftly (Kingsley 2010). The outcome was a rude awakening as I collided head on with a heavily politicised landscape populated by twitchy gamekeepers.

Experts I approached in the UK to grasp how the threat of bottom fishing on marine ecosystems was being managed, and to discuss how lessons might be transferred to archaeology, were quickly silenced. The menace of a new emerging risk that might dilute or divert funds from established research streams threatened the grants they received from UK fishing industry watchdogs. Beleaguered by high-visibility scandals about unsustainable fishing quotas, species collapse, by-catch waste, enforced boat decommissions, zoning, foreign intrusion into British fishing grounds and European Union legislation, the abrupt appearance of a whippersnapping whistleblower was hugely unwelcome.

The UK's Joint Nautical Archaeology Policy Committee tried to suppress and discredit all research coming out of Odyssey Marine

Exploration as part of a ferocious campaign to stop the Americans excavating the First Rate HMS *Victory*, the greatest warship of the Early Georgian era discovered by Odyssey in 2008 marooned in international waters (Cunningham Dobson and Kingsley 2010). While some evidence for fishing impacts on the *Victory* was open to interpretation and polite debate, the causes underlying other evidence, including unique 3-ton bronze cannon dragged by trawlers up to 233 metres offsite, was indisputable. The intention of sharing scientific data about the dilemma of managing shipwrecks outside territorial seas subjected to the spectre of fishing damage nevertheless found itself sacrificed in the fight for *Victory*. If landlubber heritage campaigners acknowledged the large-scale erosion of the Channel's underwater cultural heritage wrought by bottom fishing, the cause for excavating an endangered *Victory* would be boosted by heavyweight ammunition.

Caught in the crossfire, perhaps I had incorrectly misread the evidence? After all, at the behest of the Joint Nautical Archaeology Policy Committee, Seafish, a government body funded by a levy collected on seafood landings, sought to dismiss the majority of fishing equipment snagged on the Channel wrecks as innocuous broken gear deliberately abandoned on dangerous hangs mapped and avoided by fishermen. The sunken past was revised as a series of cultural islands not endangered and given a wide berth by fishing boats. This political climate of denial failed to acknowledge the equally real threat dumped gear inflicts on delicate wooden hulls and cargoes: just as the environmentally wasteful 'ghost fishing' causes nets snagged fast onto the seabed to billow eerily in the water column, and continue to catch fish that cannot be caught and sold, on a wooden wreck the same process can exert tensile pressure on timbers and artefacts, literally ripping them apart.

The more I threw the net wider chasing down comparative examples of global fishing impacts to shipwrecks, the larger the

mountain of data grew from the North Sea to Malaysia. Put bluntly, anywhere trawlers and oyster and scallop dredges worked for the nutritional benefit of society, encrusted wonders emerged from watery graves as unavoidable cultural by-catch. The situation within the Western Approaches and western English Channel turned out to be the tip of the iceberg. Moreover, as much as governments and marine ecologists had debated the nature of damage caused by fishing trawlers since 1863 in Britain, and numerous mitigation policies had been subsequently suggested and implemented worldwide under a tidal wave of publicity, marine archaeologists had failed to identify and address the problem.

The purpose of *Fishing and Shipwreck Heritage* is to frame a debate around the world's underwater cultural heritage as a casualty of bottom fishing. This book is not a personal crusade or part of a political campaign. Lord Byron's observation that 'Man marks the earth with ruin – his control stops with the shore' may have been true in 1818, but today mankind's burgeoning population forces us increasingly deeper into the oceans in search of nutrition, energy and resources. A summary of the threats to the planet's estimated three million shipwrecks, to compare and contrast with fishing impacts, leaves no illusion that the sunken past is no Disneyesque wonderland where gleaming cargoes and sturdy hulls lie frozen in time and inner space (Chapter 1). In the near-absence of quantitative information or empirical data, identifying the very existence of a problem, let alone assessing its scale or proposing mitigation options, is impossible. For these reasons, this book dedicates two core chapters to chasing down and summarising the trail of evidence snagged in fishermen's nets for the first time to provide a data set to debate, and examines its meaning (Chapter 2).

The intrusive equipment dragged by fishing boats, infamously renowned as bulldozers of the deep, is argued to be even more destructive to underwater heritage than to marine habitats: unlike

fauna and flora, shipwrecks have no capability to rejuvenate. Once a hull is struck and its cargo broken, washed away or recovered in a net, the damage is permanent (Chapter 3). The question of whether chance catches are fortuitous or decontextualised symptoms of serious devastation of entire shipwrecks is considered against individual sites recorded worldwide (Chapter 4).

On the back of this archaeological audit, the impacts to the world's underwater cultural heritage can be compared most readily to the analogy of ploughing on land, which serves as a vital counterpoint for modelling risks, management options and failure. In terms of historical consciousness it is argued that marine archaeology stands politically where our terrestrial brother found itself in 1870 (Chapter 5). The unavoidable conclusion is that bottom fishing is the greatest threat to the world's sunken past, which is experiencing an ever-increasing erosion of a finite asset for opportunities of education, knowledge and recreation.

What is the legacy we can hope to pass down to future generations? Is it too late to save the sunken past? What lessons can be transferred from aggregate dredging, pipeline cutting, combatting treasure hunting and marine habitat protection? Is zoning off wrecks as no-fish marine reserves – the optimum solution in marine conservation to protect fish stocks and enable habitat rejuvenation – a workable saviour for underwater heritage? In this high-stakes game of underwater Russian roulette, is the only truly sustainable solution preservation by record, committing to the excavation of a minority of the most significant wrecks to remove cargoes from harm's way (Chapter 6)?

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A book that takes a global approach to a sensitive issue where information is hard to find relies on the experience and knowledge of myriad specialists. I am especially grateful to Nico Brinck for discussing his work in Holland on cannon trawled up from the North Sea. Numerous marine archaeologists and biologists have generously shared information: Philip Armitage, Stuart Bacon, Carlo Beltrame, Simon Davidson, Katerina Dellaporta, Michael Flecker, Peter Holt, Michel Kaiser, Richard Keen, Axel Niestlé, Robert Peacock, Irena Radić Rossi, Miguel San Claudio, Sten Sjostrand, Sebastiano Tusa and Ton van der Horst. Ruth Thurstan most kindly sent me part of the 1863 Report of the Royal Commissioners discussing wreck fasteners off Britain.

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Lord Byron's quote from *Childe Harold's Pilgrimage* is shamelessly borrowed from Sylvia Earle's inspirational *The World is Blue* (2009: 31).

Wrecks and Time Capsules

Scattered beneath the world's oceans lie the sunken bones of an estimated three million shipwrecks – everything imaginable from Late Bronze Age merchantmen in the Mediterranean to Second World War German U-boats across the North Atlantic. As fine-grained assemblages, wrecks are characterised by an extraordinary organically wrapped thin-slice of archaeological time reflective of daily life transposed onto water. The deep where these 'time capsules' lie is typically perceived to be an alien environment, where cocooned ships frozen in time and space slumber safely far from the madding crowd.

The preservation encountered on sunken sites is superior to anything encountered on land beyond papyri and mummies in the arid environments of Egypt and China. Where the abandonment of everything from a Palaeolithic camp to a Roman villa and a medieval castle tended to be a deliberate act on *terra firma*, with belongings relocated to safety, the loss of a ship in the eye of a storm was unmanaged chaos. The majority of cargo and personal effects from a single moment in time ended up sealed in one structural space. Combined with excellent anaerobic conditions starved of oxygen, the potential of the deep to preserve wrecked organics and metals is the oceans' gift to archaeology. Since virtually all conceivable objects invented by the human mind, from staples, luxuries, grain and pepper to Late Bronze glass ingots, coinage, Roman statues and seventeenth-century golf clubs were transported by sea – history's most efficient information highway – the potential to extract primary data from shipwrecks is theoretically infinite.

Between the late 1940s and early 1980s, ‘fishmen’ (as Cousteau called early divers) and marine archaeologists alike judged the scientific value of shipwrecks according to their preservation status. Pioneer divers enchanted by the silent world waxed lyrical about pristine *tumuli* of amphoras in romanticised marine cemeteries rising proudly off seabeds between southern France and Turkey. These silent sentinels reflected the unspoilt beauty of the innocent seas. Jacques Cousteau’s experimentation with sand-sucking air lifts from 1952 to 1957 on the Grand Congloué wreck of 210–180 BC off southern France (Parker 1992: 200–201), highly popularised in *National Geographic*, triggered heady expectations for the nascent discipline’s potential. The bar of expectation was set sky high by the world’s first scientific excavation of a coherent wreck, the wonderfully preserved cargo and hull of the early third-century BC Kyrenia ship completely recovered off northeast Cyprus in 1968 (Katzev 2005).

The theory of ever purer preserved strata increasing with depth was first articulated by Willard Bascom, the pioneer of deep-sea shipwrecks, who anticipated that the deeper you dive, the more miraculous the preservation, especially beyond 200 metres (Bascom 1972):

Below the zone of light and waves the bottom is cold and quiet; chemical reactions proceed slowly. Without wave action to smash and abrade, one can visualize a ship settling quietly on the bottom to rest unaltered on the mud indefinitely. There are no plants and far fewer animals than in shallow water; there are no divers and no trawls. The sedimentation rate will vary greatly with distance from land and amount of current ... Thus, deep sea conditions greatly favour the survival of complete ships.

Sadly, modern research dismisses this image as a Disneyesque fantasy as man’s footprint on the oceans has become heavier and deeper. Only in the oxygen-starved depths of the Baltic, Black Sea and Great Lakes is the miracle of complete ships a reality. Today, commercial fishing

trawlers plough up marine habitats down to depths of 2,000 metres (Roberts 2007: 309). Oil and gas pipelines carve through seabeds beyond 3,000 metres. Mankind's ever-burgeoning population has erased large swathes of Cousteau and Bascom's noble dreamscapes. Marine archaeology's age of innocence has become a distant dream.

Out of sight, the far-reaching entangled threats to the world's underwater cultural heritage are more diverse than on land and more sensitive due to the organic fragility and rarity of the resource. Some threats, such as treasure hunting and commercial archaeology, have become the subject of obsessive heritage mania and international legislation, while others that arguably inflict a far greater impact are almost completely overlooked. The nature of these anthropogenic pressures is introduced below to frame a wider debate about comparative threat levels and to assess what management options best suit mitigation that ultimately may be applicable to sites at risk of being wiped out by bottom fishing.

Dredger destruction

Cultural damage triggered by the dredging of shipping lanes and colossal aggregate extraction for the building industry, when a grab physically bites into a shipwreck, can be a particularly aggressive form of localised mass destruction. Complete cargoes and hulls have simply been obliterated in a matter of minutes. At the more benign end of the spectrum, dredging kilometres away from a site often destabilises sediment cycles to trigger rapid downshore erosion, leaving newly exposed material vulnerable to natural destruction or looting.

Worldwide the economic obligation to maintain safe shipping channels by dredging has trumped archaeological conservation concerns, even when intrusion required removing entire sunken obstacles impeding navigation. Before the 1990s, environmental

impact assessments rarely included archaeological safety checks (Firth 2013: 46), reducing the risks to the sunken past to a lottery. Enormous riverine and marine environments were habitually disturbed. The dredging of the Algarve's Arade River is one of the highest profile examples of ongoing heritage sensitivity due to the presence of a sprawling ships' graveyard dating from the Roman period onwards. Huge volumes of sand perpetually choking the river have been dredged since 1926–1927, when 360,000 cubic metres were extracted to restore navigable depths down to 8 metres. Around 830,000 cubic metres of sand were subsequently extracted and re-deposited in 1970 on the Praia da Rocha beach, where thousands of artefacts were harvested by beachcombers, tourists, fishermen, local restaurant owners and collectors alike. Unmonitored dredging continued into the early 1990s, in total hitting ten wrecks and destroying at least four (Castro 2005: 55).

River dredging near Skien in 1950 completely tore apart the fourteenth-century Bøle ship, one of Norway's most significant medieval discoveries (Daly and Nymoen 2008). The man-made Mansfield Cut, dredged in the late 1950s on the border between Mexico and the USA to open a waterway between the Gulf of Mexico and the Laguna Madre, obliterated the *Santa Maria de Yciar* from the 1554 New Spain Fleet (Barto Arnold and Weddle 1978: 188). In Holland, the 37 million cubic metres of sediment dredged in 1987 from the Slufter, a channel of the port of Rotterdam, hit six wrecks spanning the medieval period and the eighteenth century (Adams *et al.* 1990). Dredge-‘inspired’ finds continue into the present day, as in the port of Genoa, Italy, where a 4.7-metre-long Roman ship's rudder was landed in 2013; the wreck itself remains missing in action (Tiboni 2014).

Owing to national embarrassments regarding underwater cultural heritage, the new millennium has broadly witnessed a sea change in proactive awareness and mitigation strategies. When the Bøle shipwreck site was newly dredged in 2004–2006, this time Norwegian

authorities required the developer to undertake archaeological investigations, which led to the unexpected discovery and recording of surviving remains of the vessel and its cargo, enabling the timbers felled for the ship to be dated finally to around the 1380s (Daly and Nymoen 2008: 155, 168). Since 2000 in southern Portugal, the Centro Nacional de Arqueologia Náutica e Subaquática has intervened to try and monitor the dredging of the Arade River by encouraging metal detectorists to plot finds and register them for conservation with the local museum. Analysis of past dredging campaigns to assess what data might still be saved identified sixteen sites of potential archaeological interest (Castro 2005: 58–59).

The 24-hour media lens that disseminates news far and wide through the World Wide Web makes it increasingly difficult to keep destruction silent. When routine sand dredging in 2008 for alluvial diamonds at Oranjemund on the southern coast of Namibia exposed a Portuguese merchant ship wrecked in the 1530s, media attention led to swift collaboration between the Portuguese government and Texas A&M University. The rescue excavations that resulted recorded the hull and iron cannon and saved over 40 tons of cargo consisting of thousands of gold and silver coins, tons of copper and lead ingots, large quantities of ivory tusks, food remains and sailors' possessions (Chirikure *et al.* 2010).

Whereas the dredging of shipping lanes is an obligatory by-product of maritime commerce, aggregate dredging is big business for the building industry. The UK has the largest offshore dredging industry in the world and figures for 2006 indicate an annual processed sale value of £293 million. Around 19.1 million tonnes of offshore aggregate were extracted from 105 square kilometres of UK waters in 2011 (Pugh 2008: 12; Newell 2013: 16). Mitigating the footprint of aggregates dredging on underwater cultural heritage received a timely shot in the arm in 2002 with the emergence of the Aggregate Levy Sustainability Fund (ALSF). This financial war chest, imposed on the

industry at £2.00 per tonne of aggregate extraction in 2009, enabled the effects of dredging on wrecks and submerged prehistoric settlements to be modelled and managed. Before then, predictive knowledge of the level of archaeological material surviving and possibly capable of being disturbed was predominantly desk-based theory. The new resources afforded thanks to the Fund included supplementing traditional side-scan sonar and magnetometer geophysical tools with multibeam echo sounders to generate high-density 3D visualisation data and sub-bottom profiling to map buried wreckage three-dimensionally (Firth 2013: 61).

The levy's pot of gold was a success story for a cog of marine science that has traditionally had to beg for funds at the bottom of the food chain. This white knight unfortunately disappeared in a puff of smoke in March 2011 under what the Department for Environment, Food and Rural Affairs described as 'a very tight spending context' in which underwater cultural heritage was not a priority. Although all dredging areas continue to be assessed for archaeological potential prior to the granting of a licence, the industry has had to fall back on a reactive model to identify areas of interest through the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest. This chain of reporting requires dredging industry staff to report artefacts to a Site Champion on their vessel or wharf, who then feeds on to a Nominated Contact acting for the company as a whole and finally liaises with Wessex Archaeology on behalf of English Heritage (Wessex Archaeology 2005). The scheme is entirely voluntary and is greased by little more than education and good will.

Pipelines and protection

The world's seas are criss-crossed by oil and gas pipelines essential to keep the home fires burning and industry rolling. Where pipelines

typically took little interest in shipwrecks lying in their path into the 1990s, occasionally smashing through cultural remains, in the West environmental surveys increasingly include archaeological oversight. Norway took the lead in enforcing legislation in the Ormen Lange project, a 1,200-kilometre, half-a-billion-dollar pipeline built between Ormen Lange in Norway and Easington in eastern England, which caters for 20 per cent of the UK's annual energy requirements.

Norway's Petroleum Act requires the industry to take precautions to avoid underwater cultural heritage; failure is punishable by a fine and imprisonment for up to two years. In 2003, an early nineteenth-century shipwreck was located along the proposed pipeline route off northwest Norway. Hull remains, glass bottles, stoneware plates, iron cannon and the ship's bell were scattered across an area of 700×200 metres. Because the Norwegian Cultural Heritage Act requires comprehensive surveys to be completed before industrial projects begin, in 2004 the Norwegian Directorate for Cultural Heritage negotiated for the developers to sub-bottom profile the wreck, cut trial pits to assess the distribution of archaeology and finally excavate the southern wreck section closest to the pipeline. The successful eight-week project conducted by Hydro custom-tooled a remotely operated vehicle (ROV) for 170-metre-deep fieldwork in a model that set the standard for the wider oil and gas pipeline industry (Bryn *et al.* 2007: 113–135).

By the time the twin 1,224-kilometre Nord Stream pipeline started to be built in 2005 to distribute natural gas across the Baltic Sea from western Russia into Europe, underwater cultural heritage was a major concern throughout the planning and operational phases. The complex international venture passed through the territorial waters of five countries. The comprehensive seabed surveys, combining remote-sensing side-scan systems and gradiometer surveys with ROV visual inspection, examined 2,500 square kilometres of the Baltic Sea. Wrecks located within 50 metres of the pipeline's route were judged to be potentially vulnerable to impacts.

A collection of twenty-seven wrecks located in Russian waters, fifty-six in the Finnish and twelve in the Swedish Exclusive Economic Zones were monitored and found to have remained stable. A historic rudder was recovered in 2009 off the island of Bornholm in Danish waters and preserved in the National Museum. In German waters the pipeline traversed the Bay of Greifswald, where fourteen ships were scuttled in 1715 during the Great Nordic War to create a 980-metre-long blockade against the Danes enjoy statutory protection. One 9.0 × 4.7-metre wreck in the pipeline's path was recorded and removed in 2009 by the Mecklenburg-Western Pomerania Office for Culture and Care of Monuments, while a second was documented and reburied 100 metres away in 2010 (Belasus 2009).

Acute awareness of the value of underwater cultural heritage is paralleled off America in the Gulf of Mexico, where the Minerals Management Service has a legislative mandate to avoid harming significant archaeological resources. Almost 25 per cent of the country's natural gas produced domestically originates in the Outer Continental Shelf, where deeper drilling incentivised by the 1995 Deepwater Royalty Relief Act is leading to increasing deep-sea shipwreck discoveries, research and promotion. A new world water-depth record was set in 2003 for drilling a well at 3,051 metres (Irion *et al.* 2008).

The Gulf of Mexico contains abundant shipwrecks due to its strategic maritime geography feeding into the Caribbean and Latin America: 6,223 sites and maritime objects excluding over 7,000 unidentified fishermen's snags (Pearson and James 2002: 86). The high-profile dissection of an early nineteenth-century schooner by an ExxonMobil Corporation pipeline, 65 kilometres southeast of the Mississippi River and detected at 807 metres in 2001 (Jones 2004: 1, 141), resulted in a sharp swing in the pendulum of consciousness. More than a dozen historic wrecks and eighteen casualties of the Second World War have been discovered and sample excavated

following oil industry sonar surveys in depths of up to 1,981 metres (Church *et al.* 2009; Ford *et al.* 2010).

Treasure hunters

Despite the huge mechanical damage inflicted by technologies harnessed for dredging and pipeline placement, nothing in world archaeology polarises public and professional opinion like the spectra of treasure hunters. Gold plucked from sunken galleys is the national lottery romanticised in the eyes of the general public. In most heritage circles, the hype of gold is mistrusted because the notion of selling shipwreck artefacts, from potsherds to coins, whether for direct profit or to channel back into funding science, is portrayed as the slaying of archaeology's most sacred cow. Treasure hunting, typically packaged as the most extreme category of shipwreck destruction, is heritage war.

The term treasure hunter actually covers a plethora of groups from happy-go-lucky divers who chance upon a wreck and fill their boots to corporations wielding state-of-the-art exploration technology, and a swathe of grey activities in between. Each group has varying philosophies, skills, finances, scientific capabilities and results. The influence of the diving public, who discover random finds or deliberately seek out 'trophies' to sell or place on mantelpieces as after-dinner conversation pieces, is underestimated. The cumulative damage inflicted by small amateur groups is nevertheless colossal. The large-scale looting of Greek to Byzantine amphora wrecks across the Western Mediterranean's shallows is a sad case in point. As UNESCO reported in 1987, of almost 400 Graeco-Roman shipwrecks discovered in France alone during the previous twenty years, all but three had been pillaged before authorities reached them (*The UNESCO Courier*, 1987). Today, almost no intact shipwrecks survive

in the Western Mediterranean above depths of 50 metres. These actions are not technically classifiable as treasure hunting.

Horror stories of destruction abound. After local divers found about 600 amphoras overlying tin ingots off Majorca at a depth of 35 metres in the early 1960s, the group dynamited the wreck and melted down 400 bars (Throckmorton 1970: 215). Comparable looting extends to the shores of the Eastern Mediterranean. Government officials calculated in 1992 that 60 per cent of all existing shipwreck finds in Israeli waters had already been illegally recovered and that very little of the country's underwater patrimony survived by 2012 (Galili and Sharvit 1992: 273). Local opportunistic individuals or small groups with no funding or strategy beyond the lure of the hunt are the cause of the majority of such looting.

Irrespective of the geographically widespread damage inflicted by recreational divers, treasure-hunting corporations are perceived to be the greatest evil and threat to the world's underwater cultural heritage. According to UNESCO, 'More than 345 large shipwrecks have been commercially exploited on a big scale in the last thirty years, with up to 500,000 objects recovered and sold per wreck, and the ship's hull left destroyed . . . Famous wrecks, damaged or destroyed by commercial exploitation, include the *Geldermalsen*, the *Nuestra Señora de Atocha*, and the Cirebon and Belitung wrecks.'¹ The trigger behind a prevailing anti-commercial philosophy is UNESCO's heavy promotion of its Convention on the Protection of the Underwater Cultural Heritage, which was specifically pushed through in 2001 to kill off 'treasure hunting'. The Annex's Rule 2 requires that:

The commercial exploitation of underwater cultural heritage for trade or speculation or its irretrievable dispersal is fundamentally incompatible with the protection and proper management of underwater cultural heritage. Underwater cultural heritage shall not be traded, sold, bought or bartered as commercial goods.

The prospect of the sale of shipwreck artefacts elicits extremely strong denunciations for good reasons. Critics rightly stress that in many cases sites are either not recorded scientifically or are seriously compromised. Contexts are often not respected. The potential to reinterpret assemblages in the future is impossible once collections are sold and broken up (Bass 1990). Wrecks subjected to treasure hunting are typically not published scientifically and fail to contribute to the sum of human knowledge. Some critics fear that in the pursuit of the one lucrative wreck, dozens of others are shamelessly torn apart and left unrecorded (Cummings 1988: 48). The despoliation of the sunken past varies from country to country, dependent on national, political and cultural regimes. Into the late 1980s, the Caribbean was plagued by treasure hunters, where gold rush fever infected the Dominican Republic, Turks and Caicos, Puerto Rico, Belize, British Virgin Islands and Jamaica, 'claiming more and more historic ship archaeological sites under the mantle of free enterprise and personal profit' (Parrent 1988).

UNESCO names and shames the Belitung and Cirebon wrecks off Indonesia as particular examples of unacceptable practice. The two hugely important ninth- and tenth-century merchant vessels are type-sites for trade between the Arab world, China and the little-known kingdom of Srivijaya in Indonesia. To what degree such criticism is justified is best explored through the high-profile case of the former discovery. Seabed Explorations tracked down the Belitung wreck in 1998, when the German company was legally awarded an excavation licence by the Indonesian government. The majority of conserved finds were sold to Singapore's Asian Civilisations Museum for \$32 million. The wreck is a unique archaeological jewel. The eclectic cargo of 60,000 conserved artefacts includes ceramics fired in at least five kilns in different parts of China that cleverly catered for foreign markets: geometric decorations and Koranic inscriptions on Changsha bowls were geared towards Islamic tastes. Three blue-and-white

dishes are the earliest intact examples of the archetypal Chinese style ever found (Guy 2010). Alongside the mainstream ceramics were exotic gold and gilt-silver vessels, perhaps imperial gifts being shipped to the Persian Gulf for a royal diplomatic wedding. Crucial analysis of the wood species identified the hull to have relied on African mahogany, convincingly identifying the Belitung ship as an Arab dhow constructed in Yemen or Oman (Flecker 2000: 213–216). An incised Chinese bowl dates the probable year of the final voyage to AD 826 (Dongfang 2010; Guy 2010), when the Belitung ship was outward bound from Guangzhou, probably to the Middle Eastern port of Al Basrah in Iraq and home of Sinbad the Sailor, when disaster struck.

Through a single site, the Belitung wreck revolutionised knowledge about Early Islamic long-distance trade sailing an unknown maritime Silk Route. Was this a success story for science and society alike, a realistic combination of commerce and archaeology for the particular case of Indonesia? When plans for the wreck exhibition's tour were advanced for the Smithsonian Museums of Asian Art, the ethics of displaying monetised artefacts was roundly denounced. The show was scrapped (for the saga and legal implications, see Coleman 2013).

An alternative approach may argue that Western attitudes to the salvage of such important heritage patronises other countries' resources and undeveloped marine archaeological regimes and tools. Commercial solutions may not be ideal, but across Southeast Asia over many years Michael Flecker, who supervised the Belitung recoveries and recorded its hull, has discovered through first-hand experience the brutal truth that since (Flecker 2002: 23):

...most wreck-sites are threatened with looting or outright destruction, the priority must be to document those sites and the artefacts recovered from them before too much information is lost. The disposition of the artefacts after thorough documentation, while of great importance, should not dictate policy, for if commercial transactions are banned

outright, the finders will be driven underground, and there will be no hope of archaeological intervention.

In commercial models of this type, governments and salvors split finds 50/50, enabling a representative sample to be retained and exhibited in the nation of discovery without paying for recovery costs. The pervading alternative in Southeast Asia to the Belitung wreck recovery model is a horror story. Innumerable wrecks have been dynamited, indiscriminately looted and dispersed through antique shops. What would have happened to the Belitung wreck if the government had not chosen to partner with a salvage firm? The alternative hardly bears thinking about. Surveys conducted around the island of Belitung between 2007 and 2010 found the remains of twenty-six formerly unknown wrecks, all but one of which had been devastated by local looters (Liebner 2014: 13). Without offering education and training backed up with funding, the West's attitude towards sites like Belitung, which were technically salvaged but from which extensive knowledge was saved and shared in public exhibitions, runs the risk of being Utopian.

Is UNESCO's anti-commerce regulation a reliable mechanism for protecting shipwrecks globally or an attempt at extremist control by heritage managers playing 'Big Brother' with flippers? Is the scale of treasure-hunting destruction truly out of control? In a journalistic flourish, Peter Throckmorton, a pioneer in marine archaeology, termed treasure hunting the world's worst investment. Throughout his career, Throckmorton became increasingly concerned by the scale of salvage he encountered across the Caribbean and Florida into the late 1980s, where he estimated about twenty-five treasure-hunting companies were touted every year for a total investment of up to \$100 million (Throckmorton 1990: 8). Throckmorton concluded: 'The hunt for antiquities has been reduced to the level of strip mining ... What we are seeing today is an assault on antiquity by an industry, not by a

bunch of small-time adventurers. In scale it is larger and better financed than any assault on antiquities in history' (1990: 8). Instead, he advocated creating museums for shipwrecks as the best way to profit financially through tourist revenue. Throckmorton estimated that such ventures yielded between three-fold and eleven-fold returns on the original wreck excavation costs.

Mixed commercial archaeology as acted out on the Belitung shipwreck is an easy target because of the media attention it attracts. But there is a world of difference between the bad old days of Caribbean treasure hunting that ripped up hulls in the search for gold, dispersed collections and resulted in no public record, and the fruits of commercial archaeology that record remains, publish comprehensively and promote public outreach. Returning to the key issue of scales of destruction versus contributions to society, commercial groups focus on a very narrow slice of the total resource. Sites of sufficient economic value to warrant organising a complex exploration project account for an estimated 0.02 per cent of the resource or 600 sites of the global total. This compares with 65 per cent of three million wrecks available for pure archaeological and historical research (Stemm 2011: ix–x).

The ethical tenets of commercial groups differ widely. During Odyssey Marine Exploration's extensive Atlas Shipwreck Survey Project, 267 shipwrecks were recorded between 2005 and 2009 across an area of 4,725 square nautical miles of the Western Approaches and western English Channel. Not a single artefact was sold. Select sampling of fewer than five artefacts for identification purposes was required for just a handful of sites. The results are being published in detail (cf. Cunningham Dobson 2011; Cunningham Dobson and Kingsley 2011; Niestlé 2011). Purists nevertheless denounce the Odyssey mixed commercial archaeology model as heritage sacrilege.

Despite the ever-escalating threats to shipwrecks, Western governments remain extremely dismissive of the concept of selling any

archaeological heritage. Exceptions do exist. In the early 1970s, Peter Throckmorton (1970: 226–227) proposed a very different approach to underwater heritage than in his later tirade against treasure hunters, whereby ‘A thousand identical amphoras of a common type simply occupy storage space in the museum unfortunate enough to acquire them. One apiece for study purposes in all museums of the country still leaves a lot left over . . . Money from the sales could go back to the service, perhaps to help excavate other sites. This is not necessarily a universal solution, but an indication that solutions do exist and can be found.’

Willard Bascom (1976: 195–196), the pioneer of deep-sea shipwreck archaeology, also condoned the exchange of artefacts to the public as one viable option to cover the costs of science. Following decades of experience working in marine archaeology, the late Professor Avner Raban of Haifa University publicly supported the sale of excavated antiquities. Raban’s amphibious tourism-commissioned excavations at King Herod’s port city of Caesarea Maritima in the 1990s recovered more than a million artefacts, most of which are legally designated as National Cultural Heritage. This vast haul led to serious soul-searching about the ethical treatment of the unmanageable. The number of artefacts worthy of regional or national museums was very small, but ‘doomed to be endlessly and at great cost “curated” (stored)’. The better quality artefacts – complete and restored vessels, coins, oil lamps and juglets – numbered in the thousands. Raban (1997: 45) was forced to conclude that:

Unlike some (or most) of my colleagues, I do not consider all archaeological artifacts ‘sacred’. The public should have a right to see and collect the extraordinary artistic products of our ancestors and the special artifacts that reflect the history of civilization, especially written documents . . . I believe it is imperative that Israel and other Mediterranean countries should now allow the sale of artifacts from legal archaeological excavations *after proper scientific publication*.

The purpose of releasing the Krakon by discussing the relative merits and pitfalls of commercial archaeology and treasure hunting is not to justify or denounce models, but to flag up the hugely varying systems in action that may be considered to mitigate the effects of bottom fishing on underwater cultural heritage.

Among the fish

The new marine archaeology that emerged during the post-1990 era is a defensive and extremely protectionist entity that cherishes the sacredness of all underwater cultural heritage. The great research projects of the 1960s to 1990s (Kyrenia, Cyprus; Yassi Ada, Turkey; Caesarea Maritima, Israel; the ships' cemetery off Dramont, southern France; the *Mary Rose*, England) have dried up because they are too complex and too expensive. The heritage pendulum has instead swung towards the ideal of protecting shipwrecks *in situ*, influentially motivated by the core tenet of the UNESCO Convention on the Protection of the Underwater Cultural Heritage (Rule 1), whereby:

The protection of underwater cultural heritage through *in situ* preservation shall be considered as the first option. Accordingly, activities directed at underwater cultural heritage shall be authorized in a manner consistent with the protection of that heritage, and subject to that requirement may be authorized for the purpose of making a significant contribution to protection or knowledge or enhancement of underwater cultural heritage.

At best, current trends have embraced green credentials, whereby over-exploitation of the Earth's natural resources has been replaced by aspirations of long-term sustainability. A selfish past is replaced by a healing present. Disproportionate attitudes and approaches still exist in the treatment of this maritime legacy. The vast scale of aggregate extraction and navigational dredging leaves a deep footprint on the

resource, which has the capacity to eradicate entire wrecks in several bites of a dredge head. The reactive voluntary system of reporting finds prevailing in the UK is based on good faith, rather than an equivalent to the 'polluter pays' principle that stands at the heart of contract archaeology on land. Meanwhile, for-profit commercial archaeology has been successfully straitjacketed by the UNESCO Convention.

Marine archaeology currently finds itself fighting a clash of cultures. Although differing stakeholders often disagree fiercely about the relative level of risks and appropriate protective mechanisms, what unites all of these potentially damaging impacts – coastal development, aggregate extraction, dredging and commercial archaeology – is that they are subjected to extensive scrutiny, debate and varying degrees of control and mitigation. Their existence is recognised and planned environmental impacts can, to a large degree, predict through desk-based studies or non-disturbance surveys the size and scope of any heritage at risk. Governments can police commercial companies with whom they have chosen to partner.

Among the froth of fervent accusations, hyperbole, legislation and shipwrecks lost and saved is a gaping anomaly – the fishing industry. Each year offshore trawling fleets dragging heavy nets and related bottom-penetrating gear sweep the oceans to feed the planet. Compared with the above impacts, bottom fishing is geographically chaotic. Rather than restricted to a small area of a port (dredging), a pre-defined concession (aggregate dredging) or focused on a single shipwreck (treasure hunting/commercial archaeology), trawlers have open access to vast swathes of the world's seas. Fishermen can change routes and regions as they chase shoals of fish on ever-more sophisticated echo sounders and multibeam technology. Trawling and scallop and oyster dredging activities have been recorded across 75 per cent of the world's continental shelves (Kaiser *et al.* 2002: 116).

Statistics compiled by the Food and Agriculture Organization of the United Nations put global capture fisheries production in 2010 at 148

million tonnes with a total value of \$217.5 billion, of which 77.4 million tonnes were caught in marine waters. By 2010, an army of 54.8 million people was directly engaged in capture fisheries or aquaculture, while the global fishing fleet contained 4.3 million vessels of which 74 per cent operated in marine waters. In total, the industry supports the livelihoods of 660–820 million people, or about 10–12 per cent of the world's population, and provides 16.6 per cent of their animal protein intake (United Nations 2012: 3, 5, 10). Fishing is huge business of major economic and social value. Current estimates suggest that trawlers sweep an area of seabed equivalent in size to half the world's continental shelves every year (Roberts 2012: 44). Compared with dredging, pipeline cutting and treasure hunting, which affect localized areas of seabed, only the effects of bottom fishing are a global continuum.

The short- and long-term impacts of trawlers, scallop dredges and other gear on marine flora and fauna have been the subject of extensive research since the International Council for the Exploration of the Sea (ICES) initiated its first inquest in 1970 (Fonteyne 2000: 16). Marine archaeology has not mirrored the progressive track of marine ecology, where bottom trawling has spawned public and academic outcry and debate, popular books, television documentaries and practical counter-measures (cf. Clover 2005). Against a backdrop of large-scale research, inquests and media attention focused on the impacts of what marine ecologists call bulldozers of the deep on the world's seabeds, the question of the fate of shipwrecks and underwater heritage impacted by heavy bottom gear has been largely neglected. No legal frameworks or best practice policies have been formulated to guide the fishing industry in how to avoid or declare snagged underwater cultural heritage. This black hole stands in stark contrast to the public obligation for industries to mitigate the imprint of offshore sand and gravel dredging and oil and gas pipeline cutting on archaeology through the 'polluter pays' principle (Irion *et al.* 2008) and the enormous attention paid to treasure hunting.

Juxtaposed with the reality that the destructive effects of bottom fishing have been reported since the fourteenth century, and the mass impacts to shipwrecks documented since the mid-eighteenth century, the subject is marooned out of sight and out of mind. Subsequent chapters present the scale and variety of material culture displaced by bottom fishing, and reconstruct the effects on the resource through individual case studies. Throughout it is argued that bottom fishing needs to be taken seriously as the greatest threat to the world's underwater cultural heritage.

Trawling the Data

Offshore fishing has stamped a heavy footprint on the sunken past, with a diverse array of archaeological finds dragged up in nets from the North Sea to the Mediterranean and from the North Atlantic to Southeast Asia. The capability for the physical interaction between bottom gear and the seabed to disturb cultural remains has piqued the interest of antiquarians since the mid-eighteenth century, when masses of pottery was caught by oyster dredges north of Herne Bay in southeast England. As fishing boat engines and gear became more powerful and heavier from the early twentieth century, everything imaginable has been snagged in nets from a Mesolithic barbed harpoon in the North Sea to a cargo of elephant tusks brought up off Brittany and the Greek masterpiece bronze statue of a life-size Victorious Youth netted in the northern Adriatic.

The surveyed data, synthesized below in order to define the history, character and geographic scope of the industry's footprint, expose fishing impacts to be a global issue extending from inshore waters hundreds of kilometres into international waters. A classification of the types of artefacts recovered is proposed. In light of the clear nature of disturbance, the crux of the debate revolves around whether society should count itself fortunate that bottom trawling results in the discovery of random underwater cultural heritage that contributes to the history of the Earth, or whether such finds are a microcosm of profound and systematic damage that merely taunts society at what is being lost.

Fished-up finds have tended to be treated as curious and unexpected gifts, a positive valuation that flies in the face of

archaeology's most sacred cow, provenance and contextual recording. Site and artefact typically remain divorced, denuding understanding of the resource. Displaced oddities frequently end up thrown back into the sea or, at best, deposited unseen in regional museum storerooms, contributing nothing to public knowledge.

Beginnings

Tales of the recovery of strange objects crafted by the hand of man caught in fishermen's nets stretch back to the mid-eighteenth century. An English fisherman, Captain Roe, raised two brass guns and other objects in 1740 from the *El Gran Grifon*, an Armada wreck of 1588 sunk off Fair Isle, Scotland (Martin 1972: 71, note 12). Ceramics plucked off the coast of southeast England since 1755 were displayed in the curiosity cabinet of the English naturalist Gustavus Brander (1720–1787) and incited great intrigue in the halls of the Royal Society of Antiquaries. In January 1778, Thomas Pownall, the former governor of Massachusetts Bay and Member of Parliament for Minehead in Somerset, described how a few years previously those curious in antiquities (Pownall 1779: 282):

... have taken occasion to observe a very peculiar kind of red earthen ware found amidst the cottage furniture of the fishermen on the Kentish coast, within the mouth of the river Thames ... some Roman vessel, freighted with these wares, must have been many ages ago cast away; and that upon the wreck of its hulk breaking up, this curious lading poured forth into the open sea on the coasts, hath been dragged up from time to time by the fishermen's nets: and the place of the wreck has been supposed to be somewhere about Whitstable bay.

Pownall's brother John, Commissioner of Excise, cracked the mysterious case by tracking down the lead. John Pownall travelled to

Whitstable and found an old fisherman who owned two or three Roman pans. The fisherman reported how during the dredging of oysters after tempestuous weather, large quantities of red pots were caught in 'one particular place, which he described to be at two or three leagues from the shore, and which was well known to the fishermen by the name *Pudding-pan-sand*, or rock'. Wishing to see the proof himself, Pownall accompanied an oyster dredge boat offshore and found the spot at the entrance to a channel at the back of Margate-sand called the Queen's Channel, two leagues from shore (Pownall 1779: 283), where:

Upon the first hale of the net, along one side of it we brought up a large fragment of brick-work cemented together, which I guessed might weigh about half a hundred weight, together with some small pieces of broken pans; upon a second hale we took up a few small fragments of pans; but upon further trial we brought three entire pans. I would have made further trials, but a gale of wind coming on, I was obliged to avail myself of the tide of flood to regain Whitstable.

The shipwreck at Pudding Pan Rock, so named because intact recovered exemplars were recycled as dessert tablewares by the wives of Whitstable fishermen, was a casualty of lying within rich oyster beds. The site has yielded a trove of intact pans in the course of 150 years of fishing (Fig. 1). In a letter to Sir Joseph Banks in April 1780, George Keate described how he, after dining with the minister of Whitstable in the summer of 1776, 'in less than an hour's walking among the fishermen's houses, purchased ten or twelve pieces, two of which were perfect and entire, and I am satisfied I might have brought away double that quantity, had I been disposed to enlarge my collection' (Keate 1782: 128). Into 1780 every dredge net cast seemingly brought up bounty. The Latin names of ALBVCINI, CINTVS, CARETI, DECMI, MATERNI and SEVERIANI stamped on the bowls identified the site as the only Roman shipwreck found off the coast of Britain (Jacob 1782: 121–122).



Fig. 1 Second-century AD Gallic Samian ware bowls from the Pudding Pan Rock shipwreck, Herne Bay, Kent, caught in oyster dredges since 1755. Photo: © Ashmolean Museum, University of Oxford (AN1896-1908 R).

A century later in 1885 the average number of red Samian ware pots fished up from the Pudding Pan Sand using rake dredges was reported as amounting to ‘about two or three dozen in the year’. At least 250 examples were known by the early twentieth century from public collections held by the British Museum, the Free Public Museums, Liverpool, the Royal Museum, Canterbury, and the Society of Antiquaries of London (Smith 1907: 275, 280). Snagged finds escalated in the early twentieth century. In 1907, dredgermen confirmed that more pottery was being raised after recent storms that had ‘caused movements in the Rock where the vessel was wrecked, and it is more exposed now’. By then, 216 stamped Latin names had been documented (Smith 1909: 399, 403).

Today, the wreck of this internationally significant site has seemingly been ploughed into oblivion. A British Museum and University of Southampton project conducted between 2000 and 2006 found no trace of what is now interpreted as at least two and possibly

three Roman wrecks in close proximity. The assemblages include a late first-century collection (c. AD 65–85) of *mortaria* and amphoras; a cargo of c. AD 175–195 comprising central Gaulish Samian ware, amphoras and one African Red-Slip bowl; and a small assemblage of early third-century material.

The case of the mysterious Pudding Pan Rock wreck is far from isolated. Fishermen dragging for lost anchors around Britain also occasionally struck wreckage, such as a sixteenth-century Portuguese brass swivel gun, almost 2.4 metres long, caught off the Goodwin Sands in 1775 (King 1779). Henry Abbinett, a diver employed by five fishermen to disentangle their nets from an unknown seabed hang off spithead, discovered the *Mary Rose* on 10 June 1836. The Whitstable diving pioneer, John Deane, then investigated the piece of wood snagging the nets and recovered a bronze cannon 3.5 metres long dating from the reign of King Henry VIII (Marsden 2003: 21).

Fishing snags are not restricted to shipwrecks, but encompass everything and anything below the waves. A fertile new area of archaeological exploration opened up in the 1860s following the discovery first by oyster dredgers and later by trawlers of vast accumulations of the bones of extinct animals in depths of 15–18 metres, 95–110 kilometres offshore at Dogger Bank in the southern North Sea. Species landed included bear, wolf, hyena, Irish elk, reindeer, red deer, wild ox, bison, horse, woolly rhino, mammoth, beaver and walrus. Over the next fifty years, ‘the whole surface of the Dogger Bank has been gone over again and again by the trawlers, and very few of the fossil bones are found; unfortunately no record seems to have been kept as to the exact place where the bones were trawled’ (Reid 1913: 39, 42). The vast prehistoric plain of Doggerland, spanning a maximum area of 260 × 95 kilometres of the North Sea between England and Denmark, was inundated c. 6000 BC at the end of the last Ice Age (Gaffney *et al.* 2009: 1, 9). Hundreds of thousands of fossil bones of terrestrial and marine Pleistocene mammals have turned up

in fishermen's nets between Britain and Holland as by-catch since 1874 without exact locational data being plotted. The National Museum of Natural History in Leiden alone holds 7,500 woolly mammoth bones (Glimmerveen *et al.* 2004: 43).

Across the North Atlantic ocean, the oystermen of Chesapeake Bay on America's central East Coast were more concerned by the dangers of their dredges hitting sunken obstacles that threatened life and limb than the curious nature of the snag. In 1884, Walter Wyman, a surgeon with the United States Marine Hospital Service, described the horrific results of striking a wreck (Wyman 1884: 278):

... when suddenly and without warning, as though an angry Titan had grasped the rope, a check is felt upon the ascending weight, the dredge rope gives a vicious jerk upon the spool, the spool reverses like a flash, and with it the iron handles revolve with terrific velocity, torn from the hands of the men as though they were made of straw ... But what has become of the four men who, but an instant before, were turning at the crank? There in the bay is one, tossed through the air, over the vessel's side, into the icy water. But his bath is insignificant. His limb struck the rail as he went over, and he has a broken leg. Here is another just regaining consciousness, with an ugly wound upon his scalp. The third may have escaped. The fourth one leans against the hatch, where he was thrown with violence, and has three fractured ribs, with laceration of the lung.

Finally, back in Europe numerous elephant tusks brought up by the fishermen of Potrieux in the 1930s gave rise to the legend of an underwater mammoth cemetery submerged in the Saint-Brieuc region of Brittany. Later surveys identified the remains as a wreck off Saint-Quay-Portrieux, possibly Dutch, dated to between 1711 and 1750 and associated with a finbanker cannon, Delft domestic pottery and glass beads (Herry 2005). The heritage of extraordinary archaeological finds of all types, dates and sizes coming up in fishermen's nets has a long tradition.

Classifying impacts

Whereas the modelling of the effects of bottom trawling on marine ecosystems is advanced, no overviews of the types of sites and artefacts impacted exist for marine archaeology. At best, a report may cursorily note the generic mode of discovery as resulting from fishing activity. With minor exceptions, the types of gear associated with the snag are rarely clarified. The available literature reveals a trail of evidence for sustained and extensive impacts since the eighteenth century, for which eight categories can be proposed:

- Class 1: artefacts recovered in static gear (gillnets, longlines, lobster/crab pots).
- Class 2: artefacts recovered in demersal trawl nets.
- Class 3: artefacts exposed and impacted on the seabed by scallop/oyster/clam dredges.
- Class 4: wooden/steel ship's structure recovered in trawl and static nets.
- Class 5: wrecks identified following the visual investigation of fasteners.
- Class 6: submerged prehistoric camps discovered through the recovery of artefacts in nets.
- Class 7: impacts identified on wrecks through trawler/scallop dredge furrows visible on side-scan sonar imagery.
- Class 8: impacts identified visually underwater on wrecks (broken artefacts, dragged and scattered structures), often in association with snagged fishing gear.

The most renowned example of a Class 1 find was a large concreted musket entwined in a lobster pot backline off Alderney in 1977 that led to the discovery of the Elizabethan wreck of an English royal dispatch carrier lost in the 1590s (Davenport and Burns 1995: 30). Lobster pot lines are considered threats to ancient wood, including

collapsed Mesolithic oak trees in the Solent, because ‘During the recovery of the pots they may become tangled in the trees and the lines between them may be dragged across the exposed deposits and features of the underwater cliff with a “sawing” action, which can be made worse if pots become tangled, further increasing both the strain on the lines and the displacement of features’ (Satchell 2011: 170).

Random finds derived from wrecks whose nuclei have never been located represent by far the most common impact category (Class 2). Their chronological range and typological variety are spectacular. A 21.6-centimetre-long Mesolithic red deer antler harpoon found in a large lump of peat caught in 1931 by the trawler *Colindia* working the Leman and Ower Banks, 40 kilometres off Norfolk and dated to 11740 $\pm$ 150 BC, triggered awareness about many thousands of fossilised animal bones and lithics recovered between eastern England and the Dutch coast in the North Sea. Waste from bone-working and implements, such as picks with shaft holes, socketed adzes and perforated mace heads, reveal the existence of a sunken Atlantis of prehistoric camps dotted among forests teeming with animals (Verhart 2004: 57; van Kolfschoten and van Essen 2004: 70–72). The discovery of the original contexts from which these materials were netted is the exception to the rule. No *in situ* camp remains have been recorded in the North Sea. One Class 6 site successfully tracked down elsewhere is the Bouldnor Cliff submerged prehistoric landscape of c. 7500–7000 BC in the western Solent, first identified in 1976 after local fishermen dredged up timbers and peat (Momber 2000: 86, 91).

The sprawling North Sea data are merely the tip of a global iceberg. Prehistoric material dating from the Palaeolithic period onwards has been caught off the UK by fishermen in Queensborough (Kent), Bournemouth and Christchurch (Dorset) and Bracklesham Bay (West Sussex), while Late Bronze Age axe heads were snagged by oyster dredgers working off Whitstable in 1916 and a Neolithic or Bronze Age trepanned skull was trawled up from the Ovingdean Gap

in East Sussex in 1935 (Firth *et al.* 2013: 92). Possible Palaeolithic bones, teeth and skulls from mammoth, mastodon and walrus have been netted off Alaska (Dixon and Monteleone 2014: 100) and the continental shelf of eastern North America (Stanford *et al.* 2014: 73–74), while scallop fishermen raked up 9,000-year-old prehistoric artefacts in the Gulf of Maine (Salter *et al.* 2014: 165–166). Commercial hydraulic clam dredges working off Nichols Point in Chesapeake Bay uncovered an important 7,000-year-old intact Middle Archaic burial, part of a wider submerged cemetery, including a human cranial fragment, stone projectile points, large stemmed knives with antler handles, quartz sidescrapers and a spear thrower (Lowery and Martin 2009: 159–160, 162–164).

Class 2 impacts have more broadly yielded almost everything imaginable within the maritime archaeological record, including organic and metallic material culture rarely encountered on land and ranging from a brass *manilla* bracelet trawled off the Grand Sole fishing bank off southwest Ireland and landed in Spain (Miguel San Claudio, personal communication, 13 February 2015) to wooden cherub sterncastle decoration from a ship of c. 1700 in the North Sea (Ton van der Horst, personal communication, 12 December 2009) (Fig. 2) and anchors weighing 3–5 tons netted off Denmark (Christoffersen 1992: 43) and Scotland (Fig. 3).

Pottery of all periods is common, such as a sixteenth- to eighteenth-century Spanish olive jar fished up in a scallop net off Beachy Head in 1924 (Curwen 1927). Intact Baetican amphoras and tableware trawled up off Aberdeen, the Dogger Bank and in the Thames Estuary point to further Roman wrecks awaiting discovery in deeper waters to add to the Pudding Pan Rock site. Scattered fragments of Dressel 1 amphoras have been netted in Yarmouth Roads (Tomalin *et al.* 2011: 4). Non-ceramic Roman material that has consistently turned up in fishermen's nets across Britain since the 1840s ranges from a *mortaria* off Beachy Head and glass vessels off Selsey to a bronze tripod leg off Sidmouth



Fig. 2 A wooden cherub from a ship's sterncastle of c. 1700 snagged in a Dutch fisherman's net in the North Sea and brought into the port of Flushing, Holland. Photo: courtesy Ton van der Horst.

(Firth *et al.* 2013: 93). Sherds from a Roman bowl caught off Denmark are stored in the Great Yarmouth Museums (inv. GRYEH:1976.67). In 1978, a trawler dredging for scallops east of the entrance to St Peter Port, Guernsey, brought up fragments of early first-century AD Dressel 7–11 Roman amphoras from a depth of 50 metres (Keen 1979: 87).

Amphoras are the most common category of artefact netted in Mediterranean contexts, such as Pot Cave off Andalusia, where since 'time immemorial' fishermen have caught jars (Guasch 1973: 113). The 200 objects in the George McGhee collection snagged off southeast Turkey between Antalya and Alanya, and the equally extensive Ruth and Yair Kennet collection fished up 5–10 kilometres off Israel (Fig. 4), span the entire history of amphora production and



Fig. 3 A collection of iron anchors caught in trawl nets off Scotland. Photo: courtesy Scottish Fisheries Museum, Fife.

trade from the sixteenth century BC to the late Byzantine era (Zemer 1977; Sibella 2002). A separate study of 433 ceramics trawled up off Israel between 1948 and 1963, dating from the Early Bronze I period (c. 3300 BC) to the Islamic era, determined that only 20 per cent of their find spots could be reconstructed (Barag 1963), which emphasises the problem of tying finds to identifiable sites.

The largest ceramic pots caught in trawl nets are the largest forms manufactured by all past societies – Roman to post-medieval –



Fig. 4 Middle Bronze Age to Byzantine amphorae in the National Maritime Museum Haifa, trawled up before 1963 in deep waters off Israel. Photo: courtesy National Maritime Museum Haifa.

typified by two stamped *dolia* of c. 50 BC to AD 50 landed from a 240-metre-deep site off Ostia, Italy (Parker 1992: 296). Another Roman *dolium* was netted on the eastern Goodwin Sands in 1860 (Redknap and Fleming 1985: 314). A jar of comparable size, inscribed 'St Aubin En Bray Oise' and made in northern France, was plucked from the waters off Guernsey in 2012 (Fig. 5). Large storage jars that once stored water on the upper decks of merchant vessels tend to be the first finds disturbed by trawlers working off Malaysia that betray the presence of a wreck (Sten Sjostrand, personal communication, 13 January 2015). At the other extreme, a small (27.2 centimetres high) but rare unglazed Mamluk earthenware bottle with moulded decoration recovered in a trawl net off Start Point, south Devon, was probably made in Syria or Palestine in the fourteenth century (Armitage and Armitage 2005) (Fig. 6).

Cannon are also common heavyweight finds (Figs. 7–9). An iron gun trawled up by a Lowestoft trawler off Kessingland, Suffolk, in



Fig. 5 A large jar fished up in nets off the Channel Isles in 2012 (H. 69 cm), inscribed 'St Aubin En Bray Oise', a region of northern France. Photo: courtesy David Wilkinson.

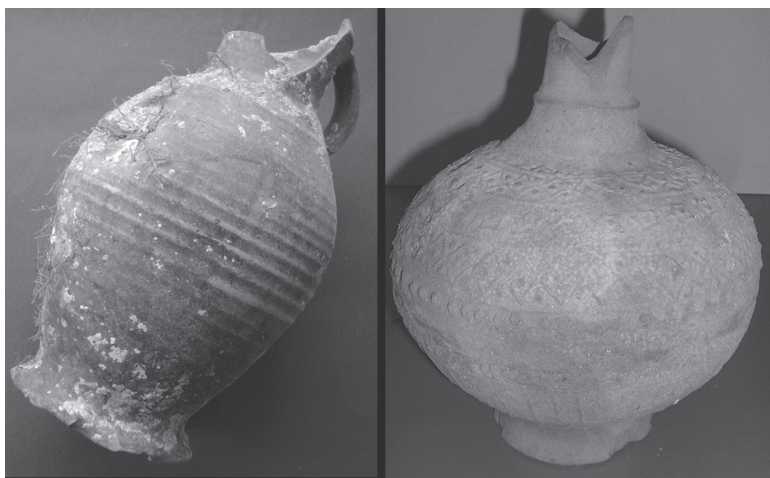


Fig. 6 Left: a Langerwehe stoneware jar of c. 1500 from Germany, recovered off Scotland. Photo: courtesy Scottish Fisheries Museum, Fife (ANSFM: 1990/22). Right: a fourteenth-century Mamluk bottle (H. 27.2 cm) recovered in 1994 in a trawl net off Start Point, south Devon. Photo: courtesy Brixham Heritage Museum.



Fig. 7 An iron cannon trawled up by a Lowestoft trawler off Kessingland, Suffolk, in 1975. Possibly from the *Royal James* lost at Solebay in 1672. Photo: courtesy Stuart Bacon, Suffolk Underwater Studies.

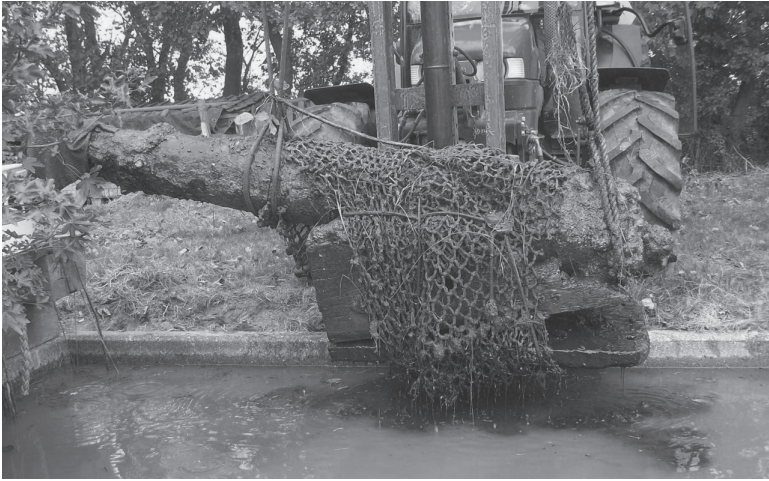


Fig. 8 A 6-pounder Finspong iron cannon and intact gun carriage dated 1696 trawled up and landed on Texel around 2010. Photo: courtesy Nico Brinck.



Fig. 9 A 24-pounder iron cannon from the Dutch warship *Delft*, lost during the Battle of Camperdown in 1797, snagged by a trawler in 2014 and landed in Stellendam, Holland. Photo: courtesy Nico Brinck.

1975, possibly originating from the warship *Royal James* lost during the Battle of Solebay in 1672, was not conserved and dried up and shattered (Fig. 7). Snagged gun carriage and decking were thrown back into the sea at the time of discovery (Stuart Bacon, personal communication, May 2011). In 1980, the *Decco 7* operating 72 kilometres off the mouth of the Chesapeake entangled its net on a 180-kilogram concretion that was sold to the Mariners' Museum and proved to be a 2-pounder iron cannon associated with a wooden sabot and canvas shot bag containing twenty-seven multi-sized iron shot (Rodgers 1989). An iron gun fished up 64 kilometres southeast of the Shetland Islands off northeast Scotland in 1994, allegedly cast at the Hirwaun Furnace in Breconshire in 1780–1786, was donated to the Fraserburgh Heritage Centre (Kingsley 2012: fig. 16). A 2.06-metre-long Venetian 12-pounder was similarly snagged in 2009 off Porto Garibaldi, Ferrara (Beltrame 2014: 43). Off Spain, the Guardia Civil has seized a bronze gun from fishermen and another iron cannon has been sold to a foundry as scrap (Miguel San Claudio, personal communication, 13 February 2015).

Classical metallic finds catch the public eye more than pots and guns due to their aesthetic appeal and financial value. These include a concreted mass of Roman copper coins snagged by a trawlerman off La Ciotat, France, in 1935 (Dumas 1962: 52), a hoard of 4,000 fourth-century AD bronze coins trawled up in a small amphora off La Meloria, Livorno, in 1965 and at least six Roman lead ingots, each weighing 70 kilograms, brought up from 18 metres in a single trawl net off Le Petit Rhône, France (Parker 1992: 275, 309). Museum quality finds include various bronze statue fragments and statuettes recovered at a depth of 5 metres off Ayia Galini, Greece, in 1937, possible loot carried away by the Goths c. AD 276–290; a colossal 0.7-metre head of the Roman emperor Augustus sculpted in Luna marble caught in an oyster dredge in the Rhône Delta, France; a bronze statue of a tunic-clad 'negro boy', a larger than life-size bronze bust of Demeter and a

figurine of Isis-Fortuna netted in 1963 from depths of 88 metres and 100 metres off Bodrum and Marmaris, Turkey; and a 0.51-metre first-century BC bronze satyr trawled up at the mouth of the Petit-Rhône, Saintes-Maries-de-la-Mer, in 1967 (Tchernia 1969: 490–492; Rosencrantz *et al.* 1972: 257; Parker 1992: 62, 366, 377, 453).

Fishermen dragging their nets for sponges close to the Knidian peninsula off the coast of Asia Minor brought up a veiled bronze lady in August 1953. The displeased fishermen begrudged the damage to their equipment and dumped the statue on a beach in the village of Bitez near Bodrum, where it lay neglected and covered in concretion until George Bean, a British professor at Istanbul University, salvaged the find and arranged for its conservation at Izmir (Ridgway 1967: 3–4).

Owing to their high value and alleged illicit sale, many statues fished from the Mediterranean have ended up ensnared in litigation. The 38-centimetre-long bronze Phoenician Melqart of Sciacca statuette trawled up by the Italian-flagged *Angelina Madre* in 1955, 20 nautical miles off Sicily, was declared state property in 1963 (Scovazzi 2010). The life-size Victorious Youth bronze statue is a Greek masterpiece dated between 300 and 100 BC that turned up in an Italian trawl net off Fano in the North Adriatic in 1964 (Mattusch 1997) (Fig. 10). Bought by the J. Paul Getty Museum in Malibu in 1977 for \$3.95 million, the artefact was ordered to be repatriated by an Italian court in 2010. The 2-metre-high, fourth-century BC ‘Dancing Satyr’, netted from a depth of 500 metres, 80 kilometres off Mazara del Vallo, Sicily, by the *Capitan Ciccio*, is also at the centre of legal wrangling over ownership between fishermen and the state (Petriaggi 2007). A recent sensation to surface was a late Classical or early Hellenistic bronze statue of a life-size boy delivered to the Greek Ephorate of Underwater Antiquities in March 2005 after recovery by a trawler fishing for cod at a depth of 500 metres west of Kythnos (Sakellariou *et al.* 2007: 367).



Fig. 10 Statue of the Victorious Youth, 300–100 BC (H. 151.5 cm). Caught by a trawler off Fano in the northern Adriatic Sea in 1964. Photo: The J. Paul Getty Museum, Villa Collection, Malibu, California, USA.

The artistic masterworks discovered, donated or declared to authorities have provided a strong contribution to the history of art. The volume of similar artworks lost to society, however, is unquantifiable, but the extremely rare bronze ram of a war galley, decorated with the head of Medusa, found by a fisherman off Sanary, France, as early as 1877, and sent to a foundry to be melted down for scrap (Dumas 1962: 52), is an unwelcome marker for the fate of many casualties.

The force exerted by trawl nets, and their capacity to separate finds from wreck contexts, is demonstrated by steel sections of English and German Second World War submarine conning towers ripped up in nets around Holland and the UK (Class 4), weighing at least 9.5 tons (Axel Niestlé, personal communication, 12 February 2015) (Fig. 11). Trawlers using winches of 16-ton pulling power are considered



Fig. 11 The conning towers of the British submarines HMS *E-26* (right) and HMS *E-34* (left) lost in the North Sea in 1916 and 1918, snagged by beam trawlers and landed on the island of Terschelling, Holland. Photo: courtesy Nico Brinck.

responsible for the disappearance of most of the conning tower, bow and propeller protective cages, the rudders, torpedo tube and the crew access chute on the M24 Japanese midget submarine sunk in 1942 at a depth of 54 metres in Sydney Harbour, which was found covered in post-1960s commercial nylon fishing nets (Class 8). Rope wrapped twice around the vessel's aft hull also suggests the submarine may have been rolled by past fishing net hook-ups (Smith 2007: 5, 6, 39, 50, 65).

Considering the damage caused to heavy-duty steel vessels, a particularly worrying category of fishing impacts are the effects on delicate snagged hull timbers (Class 4), which in some positive cases have enabled wreck sites to be identified, protected and studied (Class 5, Class 8). Many typical examples are known from UK territorial waters. A 6.7-metre-long medieval rudder weighing 1.5 tons was seemingly twice caught in fishermen's nets in Rye Bay and thrown back into the sea before finally being landed in 1983 (Ferrari 1994: 129–130). The 11-metre-deep Dunwich Bank armed merchant vessel, dated to the second half of the sixteenth century, was discovered after a Southwold fisherman brought up ship's timbers and shot in a trawl net on at least three occasions between 1974 and 1993 (Wessex Archaeology 2006: 4).

The *Stirling Castle* on the Goodwin Sands was first identified when a stern trawler struck a fastener in 1979. More recently, gillnetters blown off course by currents and winds have wrought inadvertent damage. Subsequent underwater inspections revealed a gillnet snagged on the starboard bow with an upper frame missing and very large transom timbers measuring 6×0.56 metres and weighing approximately 2 tons having disappeared (Robert Peacock, personal communication, 8 and 9 March 2010). In a similar vein, the wreck of HMS *Invincible* was discovered in 1979 after local fishermen snagged large timbers and two pewter pots (Bingeman 2010: 21–22). An iron skid from a beam trawl was found seemingly caught on the sixteenth-century Gresham shipwreck lost in the Thames Estuary (Auer and



Fig. 12 A 5-metre-long Anglo-Saxon dugout or industrial trough dated to AD 775–892 trawled up off Covehithe, Suffolk, in 1998. Photo: courtesy Stuart Bacon, Suffolk Underwater Studies.

Firth 2007: 234). In 1998, a trawler dragged up a 5-metre-long Anglo-Saxon dugout canoe in the vicinity of Southwold (Flemming 2002: 35; for its interpretation as part of a fish trap, see Goodburn 2008) (Fig. 12). A Neolithic wooden dugout has been reported in the Bulgarian press as similarly trawled up off Sozopol.

The damage that bottom gear can inflict on wooden hulls is demonstrated in greater detail by four timbers caught in the net of the *Ho Bugt* trawler between the islands of Mando and Fano in the Wadden Sea, Denmark. The catch made in a single pass in 2006 consisted of a 4.05-metre-long and 0.37-metre-wide keelson and mast step, a floor timber 2.55 metres long, and two planks measuring 2.05 metres and 2.61 metres long. The timbers have been dated through dendrochronology to 1264. The find was fortunately declared to the Fisheries and Maritime Museum in Esbjerg, and the dutiful

trawler even participated in subsequent surveys (Byskov 2006; Auer *et al.* 2008).

Exactly the same character of Class 5 fishing impacts leading to Class 8 site discoveries and study is common in American waters. Florida's royal red shrimp fishery overlies the former Colonial Spain and West Indies and Americas trade routes. In 1954, a shrimp boat landed 450 kilograms of wreckage – cannonballs, metal wares and ballast – from a deep-water site off St. Augustine, Florida, identified by Seahawk Deep Ocean Technology as a vessel allegedly associated with Spain's 1715 fleet (Vorus 1997: 21), but in fact a small English merchant vessel lost around the mid-eighteenth century. Following the recovery of an iron cannon in the late 1970s, a few years later a different trawler, the *Casey Jones*, dragged a wooden figurine (10 cm high), cannonballs, olive jars and ship's timbers off the Marquesas shrimp grounds, 80 kilometres off Key West, later identified by survey as a late eighteenth or early nineteenth-century wreck (Vorus 1997: 21).

Similarly, off southwest Louisiana the 24-metre-long *Lady Barbara* shrimper was stopped in its tracks in 1979 when it snagged the *El Nuevo Constante*, a Spanish galleon lost in a hurricane in 1766. Its nets hauled up three copper ingots, each 50 centimetres wide and weighing 32–36 kilograms (Pearson and Hoffman 1995: xv, 3). Some 80 kilometres off Louisiana, another shrimp trawler landed hundreds of silver coins, which led to the infamous discovery of *El Cazador*, a Spanish warship lost in 1784 en route from Veracruz, Mexico, to New Orleans. A salvage operation recovered the ship's bell, cannon and over 12,000 silver coins in ten days, which were subsequently sold. Little detail about the unpublished site is known. Elsewhere, off Texas a huge anchor from the 1554 fleet snagged by a shrimper, whose concretion conglomerate included chain rigging and rope fragments, has been donated to Raymondville's Chamber of Commerce (Barto Arnold and Weddle 1978: 322).

Summary

As an exercise in ground truthing, scrutinising the data from widely scattered sources swiftly populates the map of fishing-related impacts. The capability of bottom fishing to disturb *in situ* forms of underwater cultural heritage has been recognised since the mid-eighteenth century. The case of the Pudding Pan Rock Roman shipwreck demonstrates that even relatively crude low-tech equipment reliant on muscle power causes intensive impacts, wiping out the only known Roman shipwreck identified off England. According to the American evidence, seabed wreckage was feared and best avoided at all costs in the late nineteenth century.

In terms of medium, gold and silver artefacts are unusual but not unknown. Objects in bronze, copper, lead and clay are common, as are steel and wood structural remains. Ivory and horn objects are rare, iron and pottery abundant. The chronological span of trawled artefacts covers the history of the world from the Palaeolithic to the modern day. Finds are distributed geographically across the globe from Scotland to Japan.

The categories of archaeological remains confronted broadly range from the works of art of Greece and Rome to Phoenician and Buddhist objects of worship. Ordnance is a strongly represented category that includes bronze and iron cannon weighing several tons, pistols, a crate of eighteenth-century rifles and, at the far extreme, complete sections of submarines. Pottery samples vary in all sizes from large Roman *dolia* and post-medieval storage vessels to amphoras and olive jars down to juglets. In terms of size, artefacts range from small Mesolithic bones to intact Neolithic and medieval wooden dugout canoes and a keelson interconnected to a mast step.

The data create a picture of extensive disturbance at sites like Doggerbank in the North Sea, and for the case of collections of amphoras plucked from the seas off Turkey and Israel. While the

preservation levels of most wrecks from which finds have been netted are mainly an archaeological black hole of knowledge, some discoveries have sealed a site's fate. At one extreme, the heavy salvage of the Spanish frigate *El Cazador* resulted in a complete loss of contextual data (only limited information exists for the coin variants recovered). The submerged Mesolithic landscape of Doggerbank was already extensively impacted by the time Clement Reid wrote about trawler intervention in *Submerged Forests* (1913). At the other extreme, positive outcomes derived from wreck impacts include the discovery and research of iconic sites of major international importance typified by the *Mary Rose* (Marsden 2003) and the Mongol fleet of Kubla Khan (Delgado 2009b).

Does the substantial ensemble of trawled finds outweigh in importance the lost and destroyed data? Balanced reasoning requires an understanding of the extent of site damage beneath the waves (Chapter 4) and more immediately of just what damage bottom fishing gear is capable of inflicting on the deep.

Bulldozers of the Deep

In the popular imagination, the isolated finds plucked from the deep in fishermen's nets may be romanticised as derived from a sparkling treasure chest frozen in time somewhere beneath the world's crashing waves. What good fortune to see such unexpected marvels that society might otherwise never have known about. The reality is starkly different. Numerous studies leave no illusion that this superficial impressionism is far removed from the chaotic reality of profound damage to shipwrecks on the sea floor (Chapter 4). Bottom fishing is objectively argued to be the most widespread source of anthropogenic disturbance to seabed communities. Marine ecologists call trawlers bulldozers of the deep with good reason. Demersal trawlers using gear dragged over the sea bottom, and dredges raking for marine molluscs (scallops, oysters, mussels, clams and cockles), physically disturb the upper layer of sediments, flattening seabeds, removing seagrass and coral, and exposing buried fauna.

The following overview of fishing bottom technologies, the scale of global trawling and its effects on marine habitats serves as a central counterpoint to evaluate the mechanics of how fishing gear correspondingly can damage underwater cultural heritage. Decades of soul searching to develop balanced solutions also forces harsh questions to be posed about why marine archaeology has failed to get to grips with bottom fishing's capacity for cultural devastation. The scale of potential destruction is only explicable through an understanding of the technologies underlying these discoveries.

Public outcry

Environmental awareness of the potentially destructive power of fishing technologies on the marine environment is a centuries-old dilemma. As early as 1376, a Commons Petition to King Edward III of England complained about newly introduced fishing gear, the ‘wondyrechoun’, a ‘three fathoms long and ten of men’s feet wide’ device that early on created the realisation (Robinson and Starkey 1996: 122) that:

... where in creeks and havens of the sea there used to be plenteous fishing, to the profit of this Kingdom, certain fishermen for several years past have subtilly contrived an instrument called ‘wondyrechoun’ made in the manner of an oyster dredge, but which is considerably longer, upon which instrument is attached a net so close meshed that no fish be it ever so small which enters therein can escape, but must stay and be taken. And that the great and long iron of the wondyrechoun runs so heavily and hardly over the ground when fishing that it destroys the flowers of the land below water there, and also the spat of oysters, mussels and other fish upon which the great fish are accustomed to be fed and nourished.

Following this early historical account of both habitat erosion and by-catch waste, Spain pioneered the industrialisation of bottom fishing during the sixteenth century to maximise yields from north Venezuela’s rich pearl beds, a source of enormous profit and taxation for the crown. In 1528, King Philip II authorised the use of dredges for one-third returns to the royal coffers, despite citizens’ complaints that the practice would severely deplete oyster beds. Even though the use of dredges was subsequently permitted only beyond 6 fathoms (10 metres), that year contemporary documents reported the first signs of ecological exhaustion. Observations reported from Spanish Cubagua and adjacent areas of Venezuela’s Pearl Coast announced the first documented case of natural resource depletion by Europeans in

the American continent (Romero *et al.* 1999: 64, 70). Colonial Spain nevertheless continued to develop mass shell extraction technology, and by 1623 several different forms of large weighted trawl-like nets and rakes towed from boats harvested the pearl fisheries of both northern Venezuela and California (Orche 2009: figs. 7, 9).

Proto-ecologists' concerns about the detrimental effects of the wondyrechoun and oyster trawls on the marine environment also accompanied the invention of the beam trawler in the fourteenth century. By 1583, the Netherlands had banned its use for shrimping in estuaries and France made its use a capital offence the following year (Roberts 2007: 138). The large-scale, intensive 'ploughing' of the seabed, however, is a relatively modern phenomenon. In Britain, the fisheries of the North Sea opened up to beam trawlers in the early nineteenth century, when West End fish were sold to London's eager upper classes. The development of the steam railway engine in the late 1820s enabled seafood to be distributed and sold across great distances while fresh on an unprecedented scale. By the early 1860s, over 100,000 tons of fish were being transported by Britain's railways each year (Roberts 2007: 141–142). The introduction of the steam trawler to Britain in 1882 expanded the geographic scope of the fishing industry and the temporal capability of trawlers to operate up to 48 kilometres offshore (Alward 1932: 9).

Even as the advantages of trawling were being widely enjoyed, politicians' concerns about the sustainability of fishing techniques were raised by trawl landing records that showed a plummeting trajectory of 66 per cent between 1867 and 1892. A series of detailed enquiries surveyed the scene in 1863, 1866 and 1883. Despite many fishers opposing trawling as wasteful and destructive in the 1866 Report of Commissioners, based on a three-year enquiry that visited eighty-six ports and posed 62,000 questions to 700 witnesses, the Commissioners recommended 'unrestricted freedom of fishing to be permitted' (Thurstan *et al.* 2014: 506–508).

The effects of trawling on seabeds, however, were already abundantly obvious by 1866 from interviews with fishermen, such as G. Cormack from Torry, who asserted that: 'I believe there is not a portion of the ground but what the trawl destroys . . . I have dragged 50 miles off Aberdeen. I have got fast there, and brought up coral about 2.5 feet in circumference, lumps of soft coral, and I am prepared to say that whatever is in the way of the beam trawler will not escape.' The 1863 and 1866 enquiries were familiar with the threat of shipwreck fasteners (Chapter 5). The official government position to trawling remained unchanged after the 1885 Commission, which concluded that without statistical information extending over many years, it was impossible to arrive at any satisfactory conclusions about the effects of trawling (Thurstan *et al.* 2014: 515, 519).

Immediately after the Second World War and the boom in human demography, fisheries development intensified dramatically as production rose from 17.7 to 28.4 million tons globally. Between 1959 and 1972, rapid geographic fishing expansion saw annual world catches rise further to 60 million tons. The introduction of technological developments such as synthetic fibres, chain mats to protect the belly of nets and more powerful ship engines facilitated substantial increases in the size and weight of fishing gear and, in turn, fishing systems that could efficiently cover huge areas of ocean (Hall 1999: 3–4).

In the early 1980s, the weight of many fishing boat beam trawls increased from 3.5 to 10 tons and formerly unexploited fishing grounds were penetrated for the first time. This period witnessed the final expansion of distant water fleets into the Indian Ocean, South Pacific and southwest Atlantic in search of high-value species, including tuna, shrimp and cephalopods. Between 1983 and 1992, annual catches soared from 68 million to about 85 million tons globally, and issues of sustainability and the environmental implications of fisheries finally became a subject of widespread concern and

environmental debate (Hall 1999: 3, 4, 49). The unsustainable scale of trawling on global fishing communities in the wake of the widespread overexploitation of resources has been acknowledged and examined critically for over sixty years. Severe overfishing in many developing countries resulted in a series of dramatic fishery collapses.

As a consequence of the threat of uncontrolled expansion, the International Council for the Exploration of the Sea (ICES) initiated an inquest in 1970 into the effects of trawls and dredges on seabeds (Council Resolution 1970/5/1). This was followed in 1988 by the ICES Study Group on Effects of Bottom Trawling, convened in response to Council Resolution 1987/2/7 to collect information available since 1972 and to report on the development of bottom trawling gear, existing literature, national studies and proposals for coordinated research (Fonteyne 2000: 16). As a consequence of this ongoing monitoring, manifold issues of zoning, fish quotas and trawler decommission have been heavily debated and implemented.

Bottom trawling gear

The reason for this acute concern is the inability of the technologies developed for bottom fishing to enable sustainable rejuvenation of fauna or flora. Trawling gradually lowers the physical relief of habitats. Direct contact with the seabed using ground ropes, chains, bobbins, sweeps, doors, chaffing mats and parts of the net bag causes varying degrees of scraping, penetration, pressure, sediment suspension, habitat destruction, burying and benthos mortality. Although contrasting views are held about the severity of trawling, its existence is indisputable.

The methods employed by commercial fishermen for demersal catches are largely variations of trawl nets, otter trawls and dredges (for imagery of these technologies, see Galbraith *et al.* 2004: 11, 13,

31). Beam trawlers used mainly to catch flatfish and shrimp tow nets with a cone-shaped body closed by a bag or cod end (Fig. 13). The net is kept open by a horizontal steel beam 4–12 metres long. Modern beam trawlers usually tow two beams to create stability, one either side of a boat. Tickler chains are attached between the steel runners to disturb flatfish from the seabed, but on rough ground are replaced by a chain matrix to prevent boulders catching and damaging the net. Complete beam trawls of up to 3.5 tons total weight in the late 1960s had reached up to 10 tons by the early 1980s. Towing speeds vary between 2.5 and 7 knots (Nédélec and Prado 1990: 25; Jones 1992: 60; Gray 1995: 7–8; Grieve *et al.* 2014: 36).

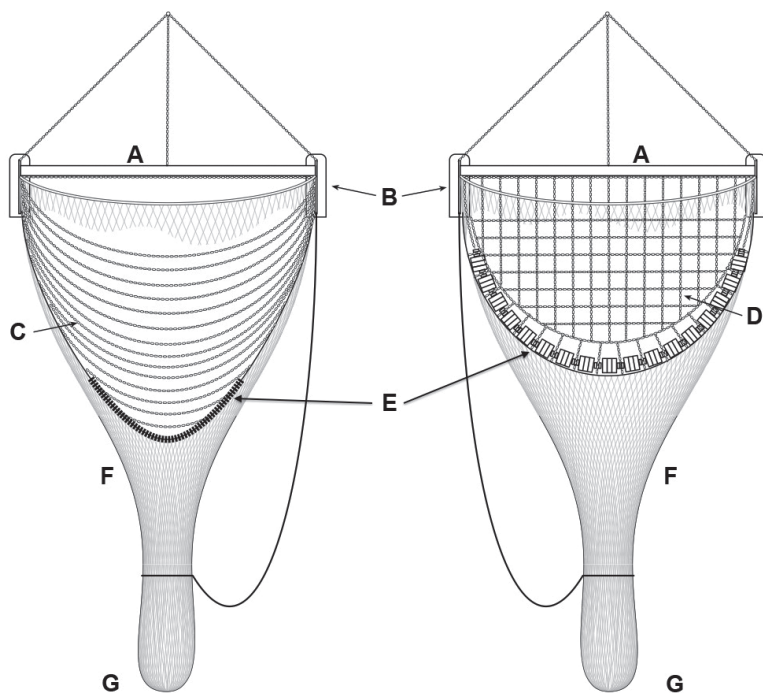


Fig. 13 Beam trawl gear towed on either side of a boat. (A) Beam. (B) Steel beam heads. (C) Tickler chains. (D) Chain mat. (E) Footrope. (F) Trawl net. (G) Cod end. Photo: after Galbraith *et al.* (2004: 19).

In the case of otter trawls, the mouth of the net is held open by weighted ground rope, floats on the headline and the lateral paravanning effect of boards or doors. The trawl doors (otter boards) are rigid structures that use hydrodynamic forces and weight to depress the trawl to the seabed. Tickler chains attached along the front of the gear disturb and propel flatfish into the path of the net. The use of large rubber discs or steel bobbins on the ground rope (rock hopper gear) enables trawls to be towed over rocky ground. This technology can sweep a wider area than the normal trawl, causing more fish to be herded into the mouth of the net. Otter boards on commercial vessels are on average 2 metres wide and towing speeds range from 2 to 6 knots (Nédélec and Prado 1990: 26; Gray 1995: 7; Vanstaen *et al.* 2008: 13; Grieve *et al.* 2014: 41).

Dredges are dragged along seabeds to dig or scrape up molluscs, such as scallops, oysters, mussels, clams and cockles (Fig. 14). The gear consists of a low rectangular steel frame at the front, with a sieve-like steel ring chain mesh bag attached behind to retain the molluscs, reduce damage from rough ground and allow water, mud and sand to run out. Dredges with a toothed bar are primarily used on fine sediment where there is less risk of gear damage. On harder substrates, damage to the toothed bar is minimised by attaching two shock-absorbing springs to the frame, which give during impact (the Newhaven dredge). Dredges are generally 0.8 metres wide and each bar is designed with approximately nine teeth typically 8–11 centimetres long. A fully rigged dredge may weigh approximately 150–175 kilograms in air. Because queen scallops rest on the seafloor, not under it like king scallops, the tooth bar is replaced with a tickler chain on skid dredges used for this demersal species. Multiple dredges are attached to a single wheeled towing bar or beam and a vessel will generally operate two beams towed either side of a boat. Up to twenty-two dredges per side may be operated, depending on the vessel's size, power and local regulations (Nédélec and Prado 1990: 31; Gray 1995: 8–9; Grieve *et al.* 2014: 50; Howarth and Stewart 2014: 11, 13, 15–16).



Fig. 14 A scallop dredge being landed off the coast of America. Photo: NOAA Central Library Historical Fisheries Collection (inv. fish6084).

The *rapido* trawl is a variety of dredge used off Italy and in the North Adriatic to capture mainly flatfish, Norway lobster, scallops and sole. The gear uses a dredge equipped with a toothed beam, typically 3 metres wide, with a mesh bag and reinforced rubber belly matting

for the retention of the catch. Each dredge weighs approximately 170 kilograms in air and is fitted with approximately thirty-two fixed teeth extending below skids. Up to eight dredges may be operated by a single vessel (Grieve *et al.* 2014: 51).

The hydraulic dredge is technologically a very different type of extremely intrusive bottom fishing gear used to harvest burrowing bivalves, such as cockles, on sandy or finer substrates. The equipment uses a drilled-out hollow blade through which high pressure water jets excavate sediments and then uses suction to pull sea bottom material to the surface, where shellfish are sorted (Grieve *et al.* 2014: 53). A hydraulic escalator version that penetrates benthos by up to 80 centimetres, sieving all objects over 3 centimetres long and carrying them to the surface on a conveyor belt, has been in use since the 1940s in South Carolina state waters to efficiently harvest clams and oysters (Barnette 2001: 12; Lowery and Martin 2009: 160).

In addition to trawlers and dredges, offshore impacts include fishing with gillnets over shipwrecks and the laying of lobster/crab pots. Gillnets are fixed to the seabed over rough ground and wrecks by weighted ground rope and anchors or other weights and kept taut by a series of floats attached to the head rope to catch cod, pollack, ling, conger eels, rays and dogfish. Boats 6–8 metres in length can set over 5,000 metres of net (Gray 1995: 10, 66). Offshore lobster and crab potting is an extensive and lucrative activity worldwide. A pot used to catch crustaceans is generally comprised of a steel frame covered in netting forming the trap, which is anchored by a weighted base. Common types are the inkwell and parlour pot and D-shaped creels. Powerful hydraulic capstans enable a two-man crew to work up to 700 pots in a day. Boats nearing 10 metres in length and crewed by three fishermen can work in excess of 1,000 pots. Since the 1980s, large pot boats, some over 20 metres long and capable of working in excess of 2,000 pots, have been constructed with live storage facilities on board to exploit offshore stocks (Gray 1995: 13; Galbraith *et al.* 2004: 30).

Quantifying trawler disturbance

All forms of deep-sea fishing have an impact on the seabed. Studies into the environmental effects of the industry demonstrate how poorly developed the management of marine archaeology remains compared with other areas of marine science and, simultaneously, provide key insights into impacts on the sea bottoms where shipwrecks lie. Bottom fishing is one of the most widespread sources of anthropogenic disturbance of seabed communities worldwide. The ecosystem effects of trawling affect species diversity, community structure and size composition (Kaiser *et al.* 1998: 354; Kaiser *et al.* 2002: 116). Trawling and dredges physically disturb the upper layer of sea bottom sediments, scraping, penetrating, flattening the seabed and exposing shell debris at the surface and buried nutrients to the water column. Tickler chains attached between the beam and foot rope are designed to exclude rocks from the gear as they penetrate the upper centimetres of substratum to disturb and fluidise the top layers of sediment and drive flatfish from the seabed into the net (Linnane *et al.* 2000: 14; Duplisea *et al.* 2001: 1). These inevitably damage infauna and epifauna. A typical beam trawler towing two 12-metre-wide nets at 6 knots can impact about 535 square kilometres of substratum in 2,000 hours in the North Sea (Duplisea *et al.* 2001: 1, 5).

Shellfish dredges, otter trawls and heavy flatfish beam trawls cause the most extensive disturbance because they are in direct contact with the seabed (Kaiser *et al.* 2002: 118). The scale of impact is not regular, but is determined by various conditions: the speed of towing, the physical dimensions and weight of the fishing gear, the sedimentological form of substratum deposits, and the strength of currents and tides. The most dynamic changes affect the surface topography. Seabed flattening results in the removal of weed, seagrass and coral. Trawling over time gradually lowers the physical relief of a habitat with potentially deadly consequences for some species. The impact of the

re-suspension of sediments and fragmentation of rock and biogenic substrata causes a release of nutrients from within sediments and exposure of the anoxic layers (Kaiser *et al.* 2002: 119–120). Two problems are created for shipwreck deposits. Buried strata become exposed to oxygen and thus deterioration, and are vulnerable to ongoing destruction as seabed erosion continues. The common practice for fishermen to re-trawl an area shortly after being fished due to the exposure of nutrients during the first pass, which attracts a frenzy of fish to the freshly ‘ploughed’ area (Hall 1999: 60), has obvious destructive repercussions for newly impacted shipwrecks pounded repetitively. Estimates suggest that some preferred areas of fishing might be visited up to 400 times a year (Kaiser *et al.* 1998: 354).

Beam trawl gear can generally penetrate bottom sediments by depths of 1–8 centimetres, depending on the speed of towing and sedimentological matrix (Grieve *et al.* 2014: 36). Some arrays with fifteen tickler chains (weighing around 1.5 tons) only penetrate less than 3 centimetres at speeds of 2.2 knots. Elsewhere, 9.5-metre-wide beam trawls fitted with seventeen tickler chains have disturbed seabeds to depths of 10–20 centimetres (Fonteyne 2000: 16–17, 34). The North Sea’s Dutch trawlers that have netted such an abundance of Mesolithic animal bones travel in loop patterns at 5–7 knots, along track lengths of 10–13 kilometres and penetrate the seabed to depths of 4–8 centimetres in a single pass (van Kolfshoten and van Essen 2004: 71). Otter boards may penetrate just 1 centimetre in coarse sands, while 2-metre-wide examples can cause significant furrows in the seabed up to 20 centimetres deep. Maximum cutting depths of 30 centimetres have been recorded. Scallop dredges typically physically disturb the upper 2–6 centimetres of the seabed, although maximum cutting depths up to 15 centimetres are known (Hall 1999: 49; Linnane *et al.* 2000: 15; Barnette 2001: 15, 22; Vanstaen *et al.* 2008: 13–14). Cumulatively prolonged bottom fishing by trawlers and dredges leaves behind an ever-eroding seabed surface.

A single pass of a beam trawl can kill 5–65 per cent of the resident fauna on the seabed for larger invertebrate species (Duplisea *et al.* 2001: 1). Single acute dredge events can even lead to 76 per cent population reductions. Repeat chronic dredge towing is predicted to lead to 93 per cent reductions for anthozoa, malacostraca (shrimps and prawns), ophiuroidea (brittlestars) and polychaetes (bristle worms) (Kaiser *et al.* 2002: 123). More than 90 per cent of a deep-sea bank of *Oculina* corals has been destroyed by trawling between North Carolina and Florida (Stiles *et al.* 2010: 8). A single trawler can also drag up between 100,000 and 363,000 leaves of *Posidonia* seagrass per hour, reducing cover by 15–30 metres and seriously damaging the rhizome system. It is estimated that trawling has damaged 40–50 per cent of Mediterranean *Posidonia* meadows (González-Correa *et al.* 2005: 66).¹ Due to their penetrative nature and close contact with the seabed, scallop dredges – especially the toothed Newhaven form – cause substantial physical disruption by ploughing sediments and damaging organisms attached to or resting on the seabed, such as hydroids, bryozoans, sponges and maerl (a red algae that forms hard, brittle filaments made of calcium carbonate). Off Scotland, a single tow of three scallop dredges crushed, compacted and buried maerl 8 centimetres below the sediment surface and reduced the coverage of live maerl by 70–80 per cent, which displayed no signs of recovery after four years (Howarth *et al.* 2014: 20, 22, 29).

Summary

Comprehensive studies of the invasive effects of trawling and oyster dredges have spotlighted how bottom fishing profoundly disturbs the seabed and all near-surface organisms overlying and underlying it. The industry is considered far more destructive than other forms of marine impacts (Chapter 1). Research focused on the North Sea by

De Groot and Lindeboom calculated that the impact of fisheries on bottom-dwelling animals was 1,000 times higher than that reported by sand or gravel extraction and 100,000 times higher than oil or gas exploration (Clover 2005: 58–59). The total amount of sediment disturbed annually in Corpus Christi Bay, Texas, by shrimp trawling has been calculated at up to 209,000,000 cubic metres or anywhere between ten and one hundred times greater than the amount dredged in the same area during the same period for the maintenance of shipping channels (Barnette 2001: 14).

Despite some fisheries management denying that ecosystems can be adversely affected by fishing (Watling 2005: 207), the unquestionable severity of the problem has a very high profile today. In a seminal paper, Watling and Norse (1998) estimated that an area equivalent to about half of the world's continental shelves is trawled every year and drew an analogy between the effects of mobile fishing gear and the clearcutting of forests on land. They identified one major difference in the scale of the relative disturbance. Whereas forest clearcutting was estimated to fell a vast 100,000 square kilometres of woodlands per year worldwide, the area trawled annually was calculated to be about 150 times greater. Each year trawling disturbs an area of seabed as large as Brazil, the Congo and India combined and results in local and global impacts on the structure, species composition and biogeochemistry of benthic communities (Watling and Norse 1998: 1190–1192). Irrespective of criticism from some fishing industry spokesmen denouncing comparisons with forest clearcutting as 'inflammatory', Watling (2005: 206) more recently emphasised how bottom trawling globally affects 14.8 million square kilometres of seabeds annually compared with 0.1 million square kilometres net forest and woodland loss.

In *The Unnatural History of the Sea*, Callum Roberts (2007: 309) from the University of York equated bottom fishing impacts to Egyptologists opening tombs, only to find them ransacked, and summarised how in a cycle of failure, 'For decades now deep-water

trawlers have roamed the high seas, destroying habitats of incalculable biological significance; places that would be treasured in national parks if they were on land. We are losing life in the deep sea even before it has even been described by science.' In *Oceans of Life*, Roberts (2012: 44, 46) went on to explain how trawls and dredges globally 'have transformed life on the seabed, converting three-dimensional, complex habitats rich in coral, sponge, seafan and seaweed to endless monotonous expanses of shifting gravel, sand and mud', resulting in a collapse of two-thirds of the species fished since the 1950s.

In *The End of the Line*, the journalist Charles Clover (2005: 1–2) compared trawling to the brutal results of what would happen if you strung

... a mile of net between two immense all-terrain vehicles and dragged it at speed across the plains of Africa. This fantastical assemblage, like something from a *Mad Max* movie, would scoop up everything in its way: predators, such as lions and cheetahs ... family groups of warthog and wild dog ... Left behind is a strangely bedraggled landscape resembling a harrowed field.

To Clover (2005: 3), the effects of bottom fishing are 'As a method of mass destruction ... the most destructive activity on Earth.'

As sources of rich nutrients and sanctuaries for the shelter and nesting of myriad marine forms, the fates of habitats and shipwrecks are intimately intertwined in the food chain linking seabeds with dining tables. Shipwrecks struck by fishing equipment are similarly impacted as marine flora, depending on the nature of deposits (durable or delicate). When trawls or nets interact with wrecks, their impact is likely to have more long-term devastation on cultural remains than marine life. While marine habitats and populations can regenerate over time, it must be emphasised in the strongest of terms that once wooden hulls and artefacts are snagged, smashed or dragged, their fate and the loss of scientific data are irreversible.

The trail of isolated finds plucked up from the world's seas (Chapter 2) leaves no doubt that bottom fishing's footprint on underwater heritage is global. The capture in nets in the North Sea of Second World War submarine conning towers weighing at least 9.5 tons and 4-metre-long sections of wooden hull remains off Denmark leaves no room for illusion about the vulnerability of wrecks and the heavyweight capacity of bottom fishing for the mass erosion of cultural remains. What empirical evidence exists for the actual forgotten shipwrecks from which artefacts are plucked and how serious is the nature and extent of damage beneath the waves?

Scales of Heritage Impacts

The technology used in bottom trawling and by dredgers, combined with the widespread nature of the wonders coming up in fishermen's nets, leaves no room for misrepresenting the reality that shipwrecks are at a minimum as vulnerable to bulldozers of the deep as marine habitats. The outstanding question is one of realism. Should society count itself fortunate that bottom fishing results in the discovery of underwater cultural heritage or are such finds a microcosm of a deeper underlying crisis? What is the scale of the damage and is it a reasonable offset for economic or cultural gain?

A major problem in developing a deeper understanding of the effects of fishing impacts on global underwater cultural heritage is the difficulty of proving a negative. Once a beam trawler or dredge has struck a shipwreck, within a matter of days or weeks any furrows cut into the seabed (the most diagnostic evidence other than snagged gear) generally smooth over. Sea bottom form (rocky, sloped, flat, sand, gravel) is a major influence on the extent of seabed disturbance. On sediments with mainly fine particles, in some places beam trawl tracks completely fade after 37 hours (Fonteyne 2000: 15), whereas in the soft sediments of Heraklion Bay off Crete otter trawling marks persisted for over four months (Smith *et al.* 2000: 1346). In muddy sediments off Barcelona, otter door furrows remained visible for at least a year (Kaiser *et al.* 2002: 120). Yet in a popular trawl area off southern Portugal, currents contributed to rapid furrow erosion: no marks were detectable across 86.1 per cent by a manned submersible down to depths of 300 metres (Morais *et al.* 2007: 116).

The reality of short-term visibility has a direct bearing on both underwater reconnaissance and side-scan sonar assessments of the severity to which a shipwreck may be impacted. The absence of fishing furrows cannot be taken to reflect an absence of fishing activities. In addition to nature erasing traces of furrows, currents and wave motion wash away broken artefacts and smashed timbers. All that survives is a site in an ever-diminishing state of preservation, a patient whose disease most often cannot be diagnosed. Without the benefits of repeat underwater surveys, quantifying change is also impossible. The absence of evidence, of course, is very different from evidence of absence. In reality, the majority of 'isolated' cultural catches documented (Chapter 2) are rarely peripherally divorced from archaeological sites, as the following synthesis of numerous worldwide case studies underscores (discussed by geographical region).

Few thematic studies have synthesised the scattered data to assess regional, let alone global, severities of impacts with several important exceptions. In the United Kingdom, Ben Ferrari (1994) examined ceramic and glass collections hauled up by trawls and oyster dredges off the Isle of Wight, Southampton and the Shetlands. Ferrari's study, the first conducted before the millennium, considered the nature of the problem and examined a suite of solutions, concluding that 'various types of fishing gear and practice can cause a reduction in the range, quality and cohesion of material within archaeological deposits. The effect of fishing gear related impact is therefore negative – in some cases to an extreme degree.' Experimental work demonstrating the potential severity of the damage beam gear can inflict on obstructions, notably concrete-covered oil pipes, led to the further conclusion that 'upstanding wooden structure would also suffer significant trauma on impact' (Ferrari 1994: 63, 82).

Based on analyses of fishing equipment used in southeast America and the Gulf of Mexico, and observations about its effects on fish

habitats, in 2004 Michael Barnette, Founder and Director of the Association of Underwater Explorers and a marine ecologist with the National Oceanic and Atmospheric Administration (NOAA), laid out his concern that:¹

Perhaps the single greatest anthropogenic threat to a shipwreck's integrity is related to fishing activities ... Introduced to the Atlantic and Pacific coasts of the United States in 1901 and 1905, respectively, trawl gear quickly became an important component of demersal fisheries for shrimp, flounder, cod, and other species ... Both the heavy trawl doors and the taut ground line impact the seafloor. They create troughs, flatten seafloor features, and re-suspend sediments in sandy and muddy habitats. On gravel, cobble, coral, or other complex habitat areas, trawl doors scrape, damage, and denude vast areas of invertebrate growth ... Hundreds of scientific studies have documented the potential habitat impacts associated with trawl gear. Yet, few, if any, have focused on their impacts related to shipwrecks.

Drawing on Odyssey Marine Exploration's identification of 267 shipwrecks during the 4,725 square nautical mile Atlas Shipwreck Survey Project of the Western Approaches and western English Channel, assessed against overlaid Vessel Monitoring Systems (VMS) aerial surveillance of fishing boat movements and *in situ* shipwreck case studies, Sean Kingsley (2010: 230) concluded that the 'vast signature of deep-sea fishing registered' has 'been subjected to destructive hammer blows on a continuous and extreme basis in some cases'. The global archaeological evidence for trawling impacts was subsequently summarised by Kingsley and mitigation options proposed, a data-led approach which arrived at the conclusion that 'Due to the enormity and extreme pressures of seabed trawling, there is a growing realization that fishing impacts may be the greatest anthropomorphic threat to underwater cultural heritage today in terms of data loss' (Kingsley 2012: 3).

In his former capacity as President of the Institute of Nautical Archaeology at Texas A&M University, Professor James Delgado (2009a: 3) offered a more damning assessment:

The world's greatest 'museum' rests at the bottom of the sea, and it is under an unparalleled assault that makes the looting of the National Museum in Baghdad, or the Taliban's demolition of the Buddhas of Bamiyan in Afghanistan, pale in comparison. Every day deep sea trawlers smash through shipwrecks, scraping them away and destroying fragile remains of the past that have remained undisturbed for millennia ... Every shipwreck destroyed in this fashion is lost forever ... We now must take a stand against indiscriminate trawling that not only destroys archaeological sites but also wreaks terrible environmental damage on vital underwater ecosystems. We must do more than simply oppose these destructive forces – we must take positive action ... We cannot afford to simply stand by, nor can we blindly hope that opposing trawling or regulating it will solve the problem.

From a regional perspective, Joyce Steinmetz has examined commercial fish trawling and dredging impacts on mid-Atlantic ocean shipwrecks off America's East Coast by analysing a statistical database, considering shipwreck case studies and by interviewing the fishing community. The results laid the foundation to propose economically viable and motivational options to safeguard both commercial fishing gear and non-renewable underwater cultural resources (Steinmetz 2010).

During the tenth anniversary colloquium on the UNESCO Convention on the Protection of the Underwater Cultural Heritage, convened in Brussels in December 2011, several speakers addressed a session on 'Trawling and Fishing.' Between 2008 and 2010, a multidisciplinary team from the University of Rhode Island, the Institute of Nautical Archaeology (Bodrum) and the BOSAV Foundation (Bodrum) conducted an acoustic and video survey of

sixteen ancient shipwrecks around southern Turkey's Bodrum and Datça Peninsulas, many of which had been heavily damaged by trawling (Brennan *et al.* 2012). In 2013, the University of Rhode Island, Texas A&M University, Temple University (Philadelphia, USA), Luther College (Decorah, USA), the University of Sinop and Dokuz Eylül University (both Turkey) reported how a cluster of shipwrecks dating from the fourth-century BC onwards, located in depths of 100–115 metres off Sinop and Ereğli off Turkey's southern Black Sea, had been heavily and persistently damaged by bottom trawling (Brennan *et al.* 2013).

A review of the available literature related to technological causes of seabed impacts and examples of archaeological disturbance by Christopher Atkinson (2012: 3) concluded that 'Archaeologists benefit from instances when an encounter is reported and the site can be investigated; however, a great deal of damage to the site may have already occurred. There exists the need for further cooperation between archaeologists and the commercial fishing industry. It is essential that the archaeological community understand the methods, needs, and implications of the commercial fishing industry in order to communicate effectively.'

To have any hope of moving the debate forward by improving consciousness about the existence of a problem requiring the attention of archaeologists, fishing communities and politicians alike, it is essential to get to grips with how bottom fishing equipment physically interacts with cultural heritage. The following case studies set within very broad continental catchment zones (Europe, the Greater Mediterranean, the Americas, and Southeast Asia and the Far East) focus on primary archaeological evidence revealing forms and scales of impacts and damage to underwater cultural heritage.

European seas

European waters have witnessed the longest history of exploitation by bottom fishing, which has left behind a trail of forensic evidence. A colossal volume of prehistoric bones has been caught in nets since the early twentieth century from the submerged area of Doggerland, 90–110 kilometres off eastern England. The University of Birmingham's geophysical mapping of nearly 23,000 square kilometres of this former prehistoric landmass lost to sea rise c. 6000 BC estimated that as a whole around 54 per cent of the North Sea is affected by beam trawling, largely Dutch vessels, and that an estimated 57 tonnes of faunal remains may be scraped off the surface of the seabed every five years. Much of the associated finds are either dumped without recording or sold on eBay (Gaffney *et al.* 2009: 153–154). These data have disturbing repercussions for shipwrecks within the same catchment zone.

Another smaller, but rich, submerged Mesolithic landscape came to light in the mid-1980s, when various Yarmouth fishing vessels netted flint tranche axes and picks while oyster trawling in the Western Solent. David Tomalin, the Isle of Wight County Archaeologist, subsequently accompanied a fishing boat offshore and witnessed first hand a 'truly surprising' frequency and variety of artefacts coming up in an oyster dredging net. Another fisherman recalled that when oyster trawling started in the Solent region in the early 1960s, 'the quantities of trawled archaeological objects had been truly astonishing' (Tomalin *et al.* 2011: 3). A collection assembled by the oyster fisherman Michael White includes 298 Lower Palaeolithic to Bronze Age flint and stone tools, weapons and faunal remains (Wessex Archaeology 2008).

In the last ten years, Nico Brinck has recorded fifty cannon weighing up to 2.3 tons brought into the Netherlands by Dutch trawlers working in the North Sea and English Channel. An additional twenty snagged bronze cannon have seemingly been landed from the

seventy-three-gun Dutch flagship *Eendracht*, sunk in the North Sea during the Battle of Lowestoft of 1665 (Brinck 2008). These overall figures suggest by extension that since 1970 at least 200 cannon may have been caught in the nets of fishermen based in Holland. Other finds netted by Dutch trawlers include the stern section of an English submarine, submarine conning towers, complete cars, cargo containers, torpedoes, anchors, airplane engines and modern artillery and mines (Nico Brinck, personal communication, 15 March 2011).

A compelling visual image of how wrecks are susceptible to bottom fishing came to light during Odyssey Marine Exploration's Atlas Shipwreck Survey Project of the Western Approaches and western English Channel, where 112 of 267 shipwrecks displayed fishing impacts (including twenty-five wooden wrecks, seventy steel wrecks and seven submarines). These ranged from abundant nets at 108 sites to gill floats snagged on thirty-three wrecks and trawler hopper gear caught on seventeen sites. Although it is not possible to prove that all of this equipment derived from direct impacts because fishermen sometimes dump broken or redundant gear on wrecks otherwise avoided as hangs (a very different problem in its own right that can cause prolonged fabric loss due to ghost fishing), the pattern of damage is obvious. Wooden wrecks displaying disturbingly unusual, yet repetitive trends are a particular concern: absence of pottery, which is omnipresent on almost all wreck forms worldwide; net fragments embedded within the sedimentological matrix down to depths of at least 30 centimetres; furrows cut directly through sites; and dragged cannon with scratched and broken surfaces (Kingsley 2010: 207, 219–224). The surfaces of the bronze cannon on the wreck of the First Rate warship the *Victory*, located 80 kilometres southeast of Plymouth, abraded, flipped and dragged up to 233 metres offsite, typify this issue (Seiffert *et al.* 2013: 7).

An armed merchantman sunk between c. 1670 and 1690 at a depth of 110 metres in the Western Approaches (site 35F) reflects the

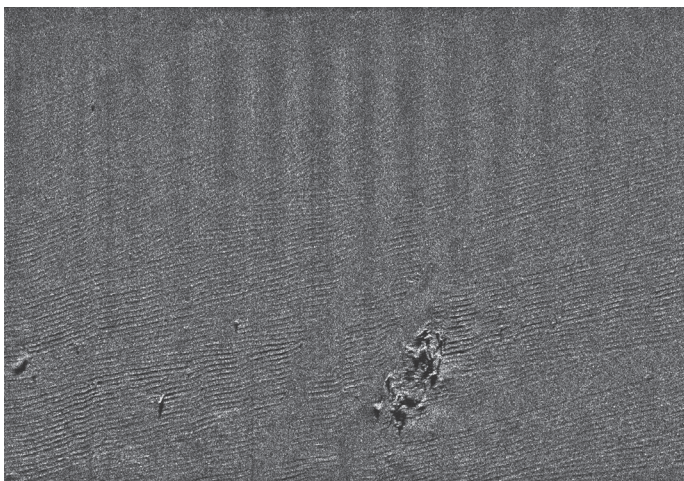


Fig. 15 A side-scan sonar image of a 110-metre-deep West Africa trader (site 35F) in the Western Approaches, showing furrow lines cut by a scallop dredge directly through the wreck. Photo: © Odyssey Marine Exploration.

worst-case scenario for the region. The wreck's surface is characterized by a poorly preserved cargo of elephant tusks and copper *manilla* bracelets on a 50-centimetre-high wreck mound possibly identifiable as a rare Royal Africa Company English armed merchant vessel trading with West Africa. The passage of trawler gear and scallop dredges has been demonstrated by indisputable interlocking evidence. Side-scan sonar captured imagery of linear, parallel-sided furrows running straight through the centre of the wreck caused by scallop vessels towing eighteen dredges per side (Michel Kaiser, personal communication, 28 February 2009) (Fig. 15). At least twelve of the ship's iron cannon have been dragged 60–300 metres offsite in different directions. Annual monitoring surveys recorded one of seven cannon overlying the keel to have been dragged and flipped between 2008 and 2009. Additional guns are abraded and broken. The concern that fishing boats can easily work across sites with low reliefs without damaging their bottom gear was demonstrated on 25 September 2006, when a passing trawler warned

the *Odyssey Explorer* to move off station so it could trawl the area. The captain stated emphatically that he had been fishing this seabed for years and that no obstruction was present on the sea bottom (Cunningham Dobson and Kingsley 2011: 4–10).

The Dutch East Indiaman the *Vliegenthart*, lost off Holland in 1735, has experienced a similar fate. The wreck was covered with nets when first discovered, one bronze cannon had been displaced and another's surface damaged by the friction of fishing cables. When fieldwork commenced in 1979, the sternpost protruded 2.20 metres above the seabed. By 2002, uninterrupted fishing activities had reduced the sternpost's height to 30 centimetres (Ton van der Horst, personal communication, 12 December 2009). A Dutch trawler snagged another of the *Vliegenthart*'s iron cannon in 2009.²

The total volume of cannon caught off the UK since the 1970s by British, Dutch, French and Belgian trawlers, retained as garden attractions, sold or left to crumble is unquantifiable. Given their status as the heaviest class of pre-First World War artefact recovered in trawl nets, individual cannon weighing up to 3 tons serve as trace elements for abundant smaller and lighter sets of material culture and wooden hull structure capable of being displaced.

The strength of submarines' steel construction, which equally succumbs to the power of modern trawlers, leaves no illusion about the extreme damage bottom fishing is capable of inflicting. The *Holland 5* submarine, lost in 1915 off the Royal Sovereign Lighthouse, Sussex, was found heavily netted in 2005 and 2006. A steel cable wrapped over the wreck had almost certainly destroyed some of the submarine's upper works and external features. Major net damage had been inflicted on the cast iron exhaust pipes leading from the top of the pressure hull over the petrol engine to the exhaust box further aft along the upper deck. Two of the four pipes had been entirely trawled off (Wessex Archaeology 2009).³ All nine German First and Second World War U-boats surveyed by Odyssey Marine Exploration in the

Western Approaches were found covered with fishing equipment. U-1208 displayed significant battle damage, which had caused the exposed frames of the pressure hull to become easy targets for trawl nets to snag on. Nets and lobster/crab creels were fastened onto the debris along the keel line of U-1201. U-327 exhibited extensive trawl nets snagged from bow to stern (Cunningham Dobson 2014).

The Greater Mediterranean

The majority of evidence from the Mediterranean realm comes from France, Italy, Greece and Turkey. The Napoleonic brick *Mercure*, lost in 1812 at a depth of 17–19 metres, 11 kilometres off Punta Tagliamento, northern Italy, is an important case study. In the mid-1980s, crushed copper cauldrons, three 24-pounder cannon balls, a sword blade and a sabre hilt were caught in fishing nets, followed by a 1.65-metre-long iron cannon recovered by the *Albatvos* in 2001. In common with the entire coast of the North Italian Adriatic, the seabed displayed widespread evidence of trawler ‘ploughing’, while side-scan sonar imagery revealed clear traces of furrows left in the seabed by *rapidi* and *turbosofianti* bottom trawls, which ‘have a devastating impact upon submarine archaeological deposits, causing damage and dislodging’. Numerous net fragments and lines littered the site, ropes and cables were found under 20 centimetres of sand, and the archaeological remains had been scattered across an area of 100 metres (Beltrame and Gaddi 2002: 60, 62).

The fate of the *Mercure* serves as a warning beacon for wider devastation across the North Adriatic, which includes a 15-metre-deep Roman wreck off Grado located 8 kilometres offshore, where trawlers have decapitated the necks of the amphora cargo (Beltrame 1998: 156–157), and damage to the Caorle I Roman wreck and a cargo of glass off Venice. The entire collection of amphoras and anchors in

the museum of Caorle ended up in the hands of fishermen, while numerous other finds have been sold to tourists (Carlo Beltrame, personal communication, 22 January 2015). Within the North Adriatic as a whole, every square metre of the sea bottom has been calculated to have been swept by trawlers at least three times. The Adriatic's approximately 500 *rapido* vessels (registered in 2011) based mostly in Ancona, Rimini and Chioggia use dredges whose iron teeth penetrate the sediment. Both the trawls and *rapido* are recognised as inducing severe and lethal damage to non-target species (Convention on Biological Diversity 2014: 4, 11).

Further south, annual surveys conducted between 2005 and 2008 by the Ufficio di Soprintendenze del Mare and the RPM Nautical Foundation on the 94-metre-deep fourth-century AD Levanzo I wreck off northwest Sicily recorded ongoing dragnet fishing (Royal and Tusa 2012: 28). Artefacts caught, damaged and dumped by ripped nets alongside snagged fishing gear were encountered in elevated rocky outcrops that blocked further dragging. The surviving wreck mound stood less than 30 centimetres high and many areas were found 'scraped clean of virtually all biological presence and loose stones, leaving a barren, flat landscape. The only features are long drag marks that crisscross the seafloor and flat rock outcrops' (Royal 2010: 9).

Fishing activities off western Sicily similarly disturbed the site of a hugely historically important naval battle fought off the Egadi Islands in 241 BC between Rome and Carthage during the First Punic War. The 2005 to 2007 fieldwork observed that the seafloor west-northwest of Levanzo Island was 'rife with long furrows from dragnet equipment; not only are artifacts scarce, but little macrofauna remains. Concentrations of artifacts were found in areas of rock outcrops ... where nets cannot enter or are caught and ripped.' Battle site trawling had netted two bronze warship rams, a bronze war helmet and numerous amphora fragments (Tusa and Royal 2012: 11–12, 29) (Fig. 16).

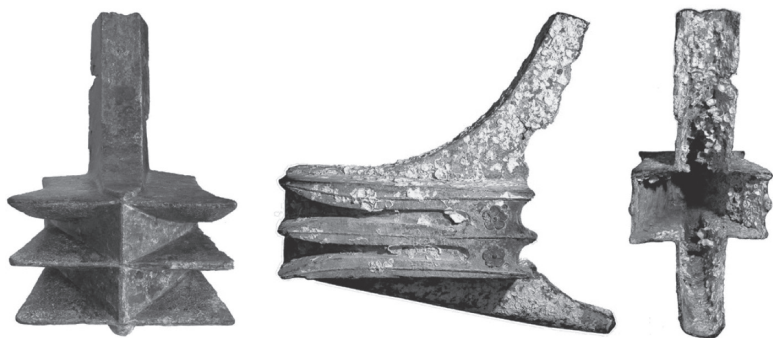


Fig. 16 The Egadi 1 bronze ram from a Roman warship sunk off western Sicily during the First Punic War and trawled up by a fisherman. Photo: courtesy Sebastiano Tusa, Soprintendenza del Mare, Regione Siciliana.

Moving eastward to Greece, in 2004 the Ephorate of Underwater Antiquities of the Greek Ministry of Culture and the Hellenic Centre for Marine Research mapped the underwater cultural heritage around Chios (7 square kilometres) and Kythnos (6.6 square kilometres) in the Aegean Sea, where down the decades amphoras and many statues have surfaced in trawl nets. Two Hellenistic wrecks were identified using side-scan sonar in areas displaying significant cod trawler furrows, several tens of centimetres deep and about 1–2 metres wide (Sakellariou *et al.* 2007: 377–378).

A detailed acoustic and visual survey project conducted from 2008 to 2010 between depths of 50 and 595 metres off southwest Turkey in the Aegean Sea by the Departments of Oceanography and History at the University of Rhode Island, the Institute of Nautical Archaeology and the BOSAV Foundation (both at Bodrum) compared the physical condition of wrecks within and outside the confines of areas excluded to trawlers by Turkey's 1971 Fisheries Law. The law is not tailored specifically to protect shipwrecks, which is a fortuitous side-effect of the prohibition against trawling within 2.5 kilometres of shore and within 100 metres either side of submarine communications cables. Sixteen wrecks spanning the fourth century BC and the sixteenth

century were recorded off Yalikhavak, Büyükkiremit, Çavuş Adası and Knidos around the Bodrum and Datça peninsulas (Brennan *et al.* 2012: 57, 60, 64).

Inside the no-trawl zones, the shipwreck formations displayed differing levels of disarticulation. Sites in naturally sheltered areas avoided by trawls as hazards pre-1971 consisted of tall mounds of intact amphoras. At the opposite extreme in open seabeds, all that remained on severely impacted wrecks trawled before the imposition of the 1971 legislation were half a dozen amphoras and small piles of ballast stones. At greater depths where the seabed is unprotected by exclusion zones, on the Knidos A, C and J wrecks (at 268–595 metres) between 25 and 40 per cent of the amphora cargoes exhibited damage. With 62.5 per cent of its cargo broken and scattered, the Marmaris B wreck was the most heavily damaged ancient wreck documented in the larger region. By contrast, within 2.5 kilometres of shore less than 1 per cent of the Yalikhavak II cargo was broken (Brennan *et al.* 2012: 64, 67). The damage to Turkey's offshore wrecks is considered 'inevitable' and the 'extent of trawling in the region suggests that there may be a greater loss of cultural sites to modern fishing activities in the Aegean than we can physically document' (Brennan 2010: 4–5).

More than 200 archaeological objects from the George McGhee collection in the Alanya Museum, including Greek to Byzantine jars recovered offshore between Antalya and Alanya (Sibella 2002), magnify the impression of broad fishing impacts over a prolonged period. A similar picture exists for Israel, where 433 largely intact ceramics, mainly amphoras, were snagged in trawl nets from depths of 18–64 metres up to 1963. The finds cover every historical period in Israel's history from the Early Bronze Age to the Islamic era (Barag 1963).

Intensive damage has been recorded by acoustic side-scan sonar and multibeam mapping and visual ROV exploration off the Turkish continental shelf in the southern Black Sea, a project aimed at

documenting the differing bottom topography spanning the oxic and anoxic interface between 100 and 300 metres. Eight of twelve wrecks recorded at depths of 101–114 metres off Sinop and Ereğli proved to have been trawled through. The 7 × 4-metre late fifth-century AD Sinop F amphora mound had ‘the appearance of a flattened top caused by the dragging of weighted fishing nets over the site’. The fourteenth- to nineteenth-century Ereğli A displayed ‘extensive disarticulation of the wooden components of the wreck by trawl damage’. On the undated Ereğli B, bottom trawls had ‘ripped apart the site, with two deep scars running directly through the center of the wreck mound’ (Brennan *et al.* 2013: 94–97).

Heavy impacts on the sixth-century Ereğli C Byzantine wreck had displaced the majority of the timbers, which lay ‘in a jumble of disarticulated fragments atop the wreck mound, although individual timbers lie scattered about the perimeter for several dozen meters, with a few located over 200 m from the main mound’. The earliest site recorded, the 23 × 8-metre late fourth- or early third-century Ereğli E merchant ship, had ‘suffered violent displacement as a result of trawling damage, the scars of which are evident on the surrounding seabed’. Wooden planks had seemingly been uprooted and overturned (Brennan *et al.* 2013: 97, 99).

Comparative photomosaics produced for the Sinop A wreck in 2000 and 2011 further indicated that during the intervening eleven years, the site had suffered serious fresh damage. Whereas an estimated 21 per cent of amphoras were broken in 2000, the figure for 2011 had more than doubled to 59 per cent. Photomosaics of other sites indicate even greater disturbance: 60 per cent of the visible amphoras on Sinop F were broken in 2011, as were 68 per cent of those from Ereğli E (Brennan *et al.* 2013: 99).

Elsewhere off Turkey, the Australian submarine *AE2* (a British E-Class submarine) sunk in 1915 and found at a depth of 73 metres in the Sea of Marmara, Turkey, has been damaged by uncontrolled fishing

activity, which fouled the hull, stripped the protective marine formations and resulting active corrosion, caused hull plates and rivets to be sprung and produced noticeable denting along the hull sides (Smith 2000: 12). These more detailed case studies confirm the generalised picture for the broader Mediterranean, as noted off Malta, in the Gulf of Naples and off Egypt (Ballard 2008: 136). Off Spain, highly destructive fishing techniques have had similarly disastrous consequences on marine fauna, 'often accompanied by the disappearance of entire undersea archaeological sites' (Negueruela 2000: 180).

The Americas

Trawlers working the waters of America have collided with important shipwrecks representative of Spanish colonial and later history since the 1960s. The 400-metre-deep Tortugas shipwreck from the 1622 Spanish *Tierra Firme* fleet came to light in the Straits of Florida in 1965 after the *Trade Winds* shrimp boat snagged an obstruction that brought the vessel to a shuddering halt. The badly damaged nets contained three intact Spanish olive jars, metallic artefacts, ship's rigging and a considerable amount of wood, including ornately carved railing (Stemm *et al.* 2013: 19, 21). The wreck lies at the heart of America's most famous shrimp fishing grounds, where 'Pink Gold' was struck in 1949 with its epicentre 112 kilometres off Key West (Van Dresser 1950).

Although the Tortugas wreck is technically coherent because the hull is preserved under a veneer of ballast, excavation in 1990 and 1991 documented conspicuous impacts, primarily cargo and domestic assemblages swept off the central ballast mound onto lower lying levels. The 209 *botijas* (olive jars), the most conspicuous artefacts featured that would have been loaded centrally, extended across an area 32.8 metres north/south and 21.5 metres east/west. Just



Fig. 17 Plan of the 400-metre Tortugas wreck, a merchantman from the 1622 Spanish *Tierra Firme* fleet, found and impacted by shrimp trawlers in the Straits of Florida. Photo: © Odyssey Marine Exploration.

26.4 per cent of the olive jars overlay the main ballast and hull area, while 73.6 per cent were closely scattered outside their perimeter (Stemm *et al.* 2013: 30, 36), a scrambled pattern attributed to shrimp fishing (Fig. 17).

A probable New York coastal schooner sunk over two centuries later during a hurricane in September 1854, 70 nautical miles off

Jacksonville, Florida, displays greater post-depositional disturbance. The 100-ton or less merchant vessel found by Odyssey Marine Exploration at a depth of 370 metres was transporting a consignment of British ceramics manufactured in Staffordshire alongside American glasswares and building materials to a southern port, most probably Savannah, Charleston or New Orleans. The 23.05×11.65 -metre wreck mound exhibited direct and indirect evidence of trawl impacts. The former included at least four parallel trawl furrows cut the length of the site from north to south on the east side of the keel that cleared sterile paths through the cargo and left behind lines of smashed ceramics and ship's hull (Gerth *et al.* 2011: 149–151, 98).

The only preserved coherent remains from the original cargo was a 4.1×1.9 -metre cluster of 238 British ceramics and glass bottles to the south of the wreck protected by a 2.38-metre-long section of durable concreted iron possibly related to the stempost (Fig. 18). This concentration of cargo, including material still stacked, and the extensively dispersed nature of ceramics and glassware across the rest

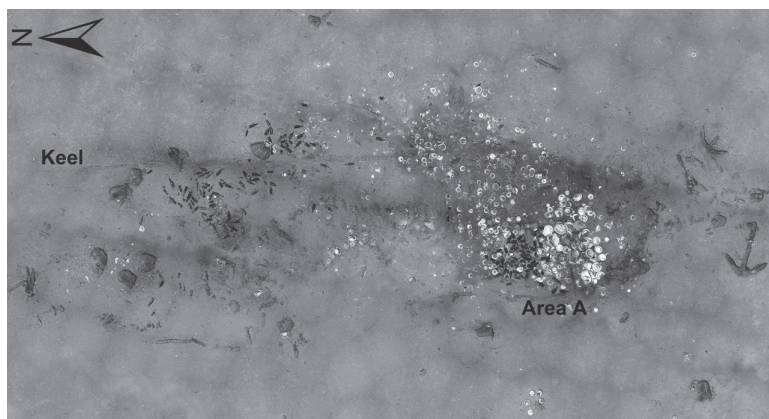


Fig. 18 The Jacksonville 'Blue China' shipwreck of c. 1854, found in 370 metres, 110 kilometres off southern Florida. Other than a well-preserved pile of Staffordshire pottery in Area A, the cargo has been heavily dragged out and destroyed east of the keel. Photo: © Odyssey Marine Exploration.

of the site, is an unbalanced and artificial pattern that does not reflect the ship's original stowage. Indirect evidence of impacts on the Jacksonville Blue China wreck takes the form of an absence of benthic organisms on a desert-like seabed and oral testimony. In 2010, local red shrimp fishermen described how they had snagged ceramics from the site throughout the last forty years using trawlers 22.5–30 metres long. One fisherman's twin shrimp trawler deployed four nets 16.7 metres long, each equipped with a tickler chain weighing 11.3 kilograms. The two trawl doors at the head of each net were 2.4 metres long, 1 metre wide and weighed 181 kilograms (Gerth *et al.* 2011: 149–150, 198–199, 202).

Off the waters of America's Stellwagen Bank National Marine Sanctuary, an 842-square-mile protected marine zone at the mouth of Massachusetts Bay managed by the National Oceanic and Atmospheric Administration (NOAA), fishing gear has impacted nearly all of its eighteen historic wrecks. Commercial fishing lands on average between 17 and 18.4 million pounds of fish and crustaceans from the sanctuary each year. Eleven of the eighteen archaeological sites contain entangled fishing gear. A trawl net is wrapped around the windlass of the *Paul Palmer*, lost in 1913, and recent impacts have broken timbers and displaced anchors. The wreck of the *Portland*, sunk in 1898, has a complete otter trawl net, including rollers and a trawl door, wrapped around its bow and starboard side. Wire towrope has cut deeply into the steamship's stempost and one of the trawl doors lies on the main deck. As well as having damaged parts of the wreck, trawl nets greatly hamper the sanctuary's ability to investigate the shipwreck archaeologically. The *Frank A. Palmer* and *Louise B. Crary*, which collided in 1902, have been negatively impacted by entangled gillnets (Studds 2008: 123, 126–127, 168). Underwater surveys initiated in 2008 revealed the 'severe impact' that fishing has inflicted because on an annual basis 'virtually every square kilometer of the sanctuary is physically disturbed by fishing activities, including

bottom trawling and dredging. Some wrecks are covered in nets while others have been stripped of all upper structure and metal hardware' (Marx 2010: 8).

Finally, a study of America's mid-Atlantic coast from Atlantic City to Virginia identified fifty-two shipwrecks at depths ranging from 20 to 76 metres, of which 69 per cent had between one and five large examples of derelict fishing gear on-site. In just one week in August 2009, four items were observed recovered by mid-Atlantic commercial fishermen, including a 3-metre ship's timber wedged inside a clam dredge, a 4.8-metre-long rudder and an anchor. Interviews revealed that scallop boats recover anchors as long as 4.6 metres and that clam dredges easily tow through wooden wrecks (Steinmetz 2010: 81, 88, 120, 124).

Southeast Asia and the Far East

The trail of cargo and hull devastation extends to Southeast Asia and the Far East along similar lines to Mediterranean and US waters. Trawling in the coastal Far East has been defined as the most serious threat to underwater cultural heritage off China and Taiwan (Kuen-chen 2006: 19). One of the most historically important wreck complexes to turn up in eastern nets are vestiges of the lost fleet of the Mongol ruler Kubla Khan, destroyed off Takashima Island, Japan, in a hurricane in 1281. A site containing warships was found after local fishermen trawling the bottom of Imari Bay for generations snagged Chinese pottery and weapons. Particularly diagnostic discoveries included a 77-centimetre-tall bronze statue netted in the late nineteenth century identified as a Kanzeon Bosatsu Buddha, a symbol of mercy revered by Mongols as protector of their armies. A bronze square seal inscribed in *Pagspa*, the official script used by the Mongolian court in China, helped confirm the fleet's sunken location (Sasaki 2008: 42; Delgado 2009b: 130).

Off Southeast Asia, most historic wrecks are discovered by fishermen, who bring them to the attention of salvors and the antiquities market due to the presence of profitable pottery. The large volume of ceramics typically transported by Chinese junks and Southeast Asian vessels makes sites across the Far East and Southeast Asia especially attractive and vulnerable. Plate and bowl pot forms are far lighter and more delicate than the Mediterranean's thick-walled amphoras. Off Thailand, pair-trawlers considerably damaged the late sixteenth-century Ko Si Chang 1 shipwreck, resulting in the destruction of ceramics, scouring and lowering of the wreck mound (Green *et al.* 1986: 116). Meanwhile, timbers projecting from the seabed at an angle of about 20° on the fourteenth- to fifteenth-century Ko Si Chang 2 shipwreck were almost certainly the result of having being hit and partly ripped out by trawlers, which also possibly explains the keel's disappearance (Atkinson *et al.* 1989: 300, 305). The mid-fifteenth-century Ko Si Chang III wreck sustained similar serious damage (Brown 2009: 46–47).

The hundred or so intact pieces of Siamese pottery found among the destruction of tens of thousands of broken ceramics littering the surface of the fourteenth- to early fifteenth-century Phu Quoc shipwreck off Vietnam were at least partly explained by trawling and the use of explosives, both common fishing methods in the area (Blake and Flecker 1994: 73, 82). The Hoi An shipwreck was infamously targeted off central Vietnam in the South China Sea using fishing nets, and 'Huge dishes, ornate dragon sculptures, and delicate vases were picked out of the nets and sold straight to the dealers' (Pope 2007: 40).

The most detailed data available for Southeast Asia come from Malaysia. Around 30 per cent of the Turiang wreck, a Chinese ship of 26 × 7 or 8 metres dated to c. 1370 transporting a mixed cargo of Chinese, Vietnamese and Thai pottery, was found scattered by trawl nets (Brown and Sjostrand 2004: 43; Brown 2009: 39). At a depth of 63 metres and 23 nautical miles off the east coast of the Malay peninsula,

the fifteenth-century Longquan wreck's 1.8-metre-high cargo of around 100,000 pieces of Chinese and Thai ceramic cargo discovered in 1996 in a hull reconstructed at over 30 metres long – one of the largest wooden ships found under the South China Sea – had been obliterated by 2001. The wreck lies on a mud seabed initially considered too soft for trawling and thus not at risk from fishing, but Thai trawlers accosted the site in the intervening years, littering the seabed with nets with the result that 'Everything was gone – spread north and south by fishing trawlers ... Now only approximately 10,000 pieces were left and most of them were smashed' (Sjostrand *et al.* 2006: 85). Much of the hull was flattened (Flecker 2012: 75–76).

The Portuguese 'Wanli' shipwreck of c. 1625 came to light off peninsular Malaysia's east coast in 1997 after a large blue and white baluster jar and other pottery appeared in trawl nets. In the wake of exploratory dives conducted the following year, 'Broken porcelain littered the seabed and it was spread a long way north and south of the site, a pattern that corresponded with the direction of trawling' (Fig. 19). An estimated 80 per cent of the ship's original 37,300 pieces of porcelain were broken, fragmented or pulverised. Three tonnes of broken porcelain lay smashed in the upper surface layer (Sjostrand *et al.* 2006: 114–115; Sjostrand and Syed Idrus 2007: 15).

The 20-metre-deep Desaru shipwreck was located two nautical miles off southern peninsular Malaysia in June 2001 when a bottom trawler twice snagged its nets and recovered potsherds and ship's timbers. When dived by Nanhai Marine Archaeology in April 2002, the site was shaved flat. Scattered potsherds covered a large area of seabed, which was 'littered with broken planks and misplaced bulkhead frames. The trawlers had destroyed most of the ship's structure above the main framework.' Further damage was inflicted between May and September 2002, even though a large wreck buoy had been placed to warn off trawlers and protect the site. Underwater, a long steel chain and nets were snagged on ship's timbers and three



Fig. 19 Pottery smashed by trawl nets on the Wanli shipwreck of c. 1625 off Malaysia. Photo: courtesy Sten Sjostrand.

large and heavy longitudinal beams from the mast support had vanished (Sjostrand *et al.* 2006: 101). At the far end of the chronological spectrum, the K17 Dutch submarine based in Singapore under the British Eastern Fleet Command during the Second World War and wrecked off Malaysia, today a designated war grave, is engulfed with tangled nets and fishing rope across almost its entire surface, including the hatch wheel (Sjostrand *et al.* 2006: 141).

The reality of fishing impacts off Malaysia has been summarised by Samsol Sahar, Curator of the Maritime Archaeology Museum in the Department of Museums Malaysia, who concluded (Sjostrand *et al.* 2006: 139, 141) that:

Today many shipwreck sites are in constant danger of being unwittingly destroyed by fishing trawlers ... who operate 24 hours a day, seven days a week. Their nets are dragged along the seabed destroying everything in their wake. A single trawl across a wreck can destroy virtually everything. Although this is an undesirable situation, it is something that is very difficult to stop because ironically shipwrecks tend to attract huge populations of fish who feed on the rotting debris and marine organisms growing on the wreck. Not being able to identify and salvage these shipwrecks before their destruction is heartbreaking.

Summary

The cross-section of sites impacted across Europe, the Greater Mediterranean, the Americas, Far East and Southeast Asia leaves no doubt that the damage fishing trawlers and oyster and scallop dredges inflict on wooden historical wrecks mirrors severe patterns long documented for marine habitats. All too often the evidential foundations required to extract the primary data necessary to reconstruct a ship's history (hull form, cargo type and size, daily life at sea) can be too diminished to be feasible. However, it is also true that a complex interconnecting set of natural, technological and archaeological X-factors dictate at the micro level varying levels of damage and preservation. What survives and what is lost has been reduced to a case of underwater Russian roulette.

In exactly the same way that many variables condition the effects of trawl damage on marine habitats and equally the ploughing of archaeological remains on land, including soil and bed rock type, topography, form and condition of the archaeological remains, previous cultivation and the type and usage of current cultivation equipment (Lambrick 1980), an interlocking set of factors determine levels of shipwreck preservation impacted by bottom fishing. These can be explained as:

1. Sediment composition and structure: wreckage deeply buried under relatively stable sediments may not be susceptible, while hulls and material culture exposed in a dynamic environment leave artefacts and timbers susceptible to impacts.
2. Site topography and elevation: wrecks lying on a flat, sandy seabed are at greater risk than those on slopes, flanked by natural boulders, undulating rock surfaces or heavy ship's structure that cushions remains from damage.
3. Natural site preservation: prior to impacts, sites may be well preserved and coherent or already badly scattered through natural deterioration or looting. Absence of data about the effects of bottom currents, tides and erosion are significant X-factors in this equation.
4. Fishing impact form: longlines or lobster/crab potting cause less aggressive forms of impact than beam trawling and scallop and clam dredge intrusion.
5. Previous impacts: the number of times that a wreck has been impacted will affect levels of preservation and mechanical erosion.
6. Historical timeframes of equipment usage: sites impacted post-1950s by bottom gear towed by boats with more powerful engines and synthetic nets (more robust than hemp) will be more susceptible to damage.

Taking these grey areas into consideration, five general categories of shipwreck impacts caused by fishing equipment can be proposed. These vary from the capability to smash artefacts, such as Mediterranean amphoras and Chinese plates (Type 1) to the common occurrence of breaking apart hull structure from strakes and frames to entire keels (Type 2). The passage of bottom gear across wrecks loosens archaeological strata, exposing organic remains to oxygen infiltration, leading to ongoing stratigraphic deterioration (Type 3).

The decontextualisation of cargoes and domestic assemblages leaves them highly susceptible to inadvertent recovery, loss in nets or destruction (Type 4). Precisely the same external pressures leave loosened hull structure vulnerable to breaking and being washed and lost offsite by bottom currents (Type 5).

A key issue raised in this book is how society should rationalise the public value of myriad isolated fishing-related discoveries. Should they be welcomed open-armed as unexpected friends or be perceived as symptoms of a malignant disease in dire need of treatment? Strong arguments certainly exist *pro et contra*. Bottom fishing has undoubtedly produced exciting finds of major international cultural value that enhance archaeological knowledge and maritime history. If the *Mary Rose* had not been snagged by nets and discovered in 1836, her preservation and ultimate fate may have followed a very different trajectory from today's public enjoyment and source of great education. The recovery in trawl nets of individual bronze statues, typified by the life-size Greek Victorious Youth in the J. Paul Getty Museum, Malibu, and the fourth-century BC 'Dancing Satyr' from Mazara del Vallo, Sicily, contribute significantly to the history of art and have enchanted millions of museum visitors.

In a similar vein, the memories of the First Punic War – incredibly rare bronze warship rams and helmets netted off the Egadi Islands – are radically revising our understanding of classical naval warfare (Tusa and Royal 2012). As a deep-sea site lost in 400 metres of water, the coherent remains of the Tortugas wreck have permitted a level of reconstruction for a 1622 Spanish fleet merchantman that is impossible for other *flota* vessels broken up and scattered across the shallow Florida Keys (Stemm and Kingsley 2013; Kingsley 2014). As the only possible Royal African Company merchant vessel trading between England and West Africa found off the United Kingdom, site 35F in the Western Approaches is a gift to post-medieval marine archaeology (Cunningham Dobson and Kingsley 2011). The *Mercure*

is an unusual example of Napoleonic era naval warfare (Beltrame and Gaddi 2002).

For the case of pottery, the Middle Bronze Age to Byzantine amphoras plucked from deep waters off Israel, and now securely housed in the National Maritime Museum Haifa (Fig. 4), have served as a foundation for developing regional typologies (Zemer 1977). Of greater immediate concern is the intimate role of fishermen across Southeast Asia bringing wrecks to the attention of archaeologists and salvors, but rarely authorities. Even such problematic paths can yield positive outcomes, including ever-improving ceramic chronologies and wider historical syntheses. The heavily trawled wreck evidence from Malaysia, for example, has made a major contribution in clarifying what products filled the Ming gap between 1352 and 1487, a period when the dominance of Chinese blue and white crashed after rebels attacked the kilns of Jingdezhen and exports were banned to enhance porcelain's imperial status inside China (Brown 2009).

Despite the romance that can superficially envelop perceptions of unexpected finds netted by fishermen, and the above exceptional outcomes, society must not be blinkered into forgetting that such discoveries equate to shipwreck erosion and lost opportunities. There is an inescapable need to adopt a hyper-realistic mentality devoid of political posturing in confronting snagged heritage management options. What might the entire contextualised statue cargoes of the Victorious Youth and Mazara del Vallo wrecks look like? Are they still tantalisingly preserved or have they been hopelessly smashed and scattered?

If archaeology's ultimate objective is to reconstruct past civilisations by converting primary data into human knowledge, rather than merely extracting silent marketable museum pieces for worship behind glass, then there is only one conclusion: we are losing the battle. Fascinating wrecks can only contribute to long-term history when the original sites from which they were plucked can be tracked

down and studied in context. Even then explorers must hope the lost site has not been ground down beyond reconstructable recognition. Whether a wreck has been newly struck or prolonged impacts have left it culturally dead is a lottery only clarified by underwater survey.

Sufficient data exist globally from disparate seas to argue for the prevalence of a global pattern, even bearing in mind that fishing technology, intensity and seabed topography differ from region to region. The cross-continental evidence must be perceived as a serious red flag. Entire submerged prehistoric landscapes have been wiped out unseen in the North Sea. How many amphora cargoes have vanished? The size, stowage character and shipboard habits of the crew of the late seventeenth-century West African merchant vessel in the Western Approaches are lost for ever despite the site's uniqueness. Large sections of marine archaeology's hard drive have simply been erased. The problem is endemic. Where do we stand in terms of management theory and how can the problem be best mitigated?

Management Myopia

Archaeologists may be forgiven for thinking that the destruction to underwater cultural heritage wrought by bottom fishing and the dilemma of struggling to enforce optimum management sounds familiar. And so it should, we have been here before in tackling the relationship between cultivation and archaeological landscapes. The prevailing global *realpolitik* is closely comparable to archaeologists' pre-First World War awakening in Britain to the effects of ploughing. In July 1870, Colonel Augustus Lane-Fox wrote to the *Saturday Review* about damage to the Iron Age *oppidum* enclosure of Dyke Hills in Dorchester, where 'At least a third of the dyke has already been lowered, and will gradually be utterly destroyed beneath the yearly passage of ruin's merciless plough share.' His concern was among several voices that inspired Sir John Lubbock's Ancient Monument Bill in 1872 (Trow 2010b: 129), which became Britain's first Ancient Monuments Act in 1882 (Lambrick 2004: 189).

Despite the dazzling technological tools of the trade available to marine archaeologists and a high media profile, political consciousness about the effects of fishing impacts on underwater cultural heritage stands where ploughing found itself in the last quarter of the nineteenth century. Around the same time that Lane-Fox's vision started the ball rolling towards terrestrial legislation, the British government's Sea Fisheries Commission enquiry acknowledged for the first time the problematic relationship between shipwrecks and fishing. Rather than question the threat to important underwater heritage, however, wrecks were perceived to be a useless danger to fishermen's livelihoods. An interview with the fisherman J. Somers on

24 December 1863 led the commission's Professor Huxley to propose that blowing up the wrecks along the west bay of Wyke Regis would be of 'great advantage'. In conversation on the same date with the fisherman R. Williams, also from Wyke Regis, Huxley was informed that when nets catch on wrecks in Weymouth Bay, one of which has been underwater 'since the remembrance of man, and has done thousands of pounds' worth of damage', fishermen lose £40 to £50 in lost fish and £5 to £10 in net damage. Abel Whittle recommended during the same set of interviews the removal of all wrecks between Portland and Abbotsbury, some 'upwards of a century old', because they had half-ruined fishermen's livelihoods (Report of the Commissioners 1866: 443–444, 447–448). Attitudes towards protecting archaeological remains on land and destroying those underwater could not have been different during the third quarter of the nineteenth century.

The challenges of heritage management in farmed landscapes serve as a close archaeological analogy and warning for the impacts of bottom fishing. Despite a long history of awareness, ploughing's severity only started to be examined systematically in the 1970s, when discussions of technologies and vertical cutting potential led to the recognition in the UK that 'Centuries of history can be destroyed for ever by one pass of the plough' (Lambrick 1977: 32). By 1970, less than 1 per cent of the Berkshire chalk, 2 per cent of Hampshire chalk and under 3 per cent of Dorset chalkland were estimated to remain untouched beneath unploughed grasslands. Cultivation was acknowledged to represent the greatest threat to archaeological sites by the early 1980s (Hinchliffe 1980). Archaeologists slowly acknowledged that 'we are facing a future that holds a completely modified rural environment; an environment in which the chances of locating and investigating well-preserved sites are rapidly diminishing ... Much of the optimism of contemporary archaeology may be misplaced' (Yorston *et al.* 1990: 67–68).

The 1995 Monuments at Risk Survey (MARS) Project quantified the scale of the threat level by sampling 5 per cent of England in the form of 1,297 randomly distributed transects measuring 1×5 kilometres and containing 14,591 recorded monuments. The results again revealed that cultivation was the single greatest hazard to the archaeology, accounting for 10 per cent of its wholesale destruction and 30 per cent of the piecemeal loss (Darvill and Fulton 1998: 3, 8). Only in the last fifteen years have practical steps towards mitigation emerged in the wake of the Management of Archaeological Sites in Arable Landscapes Project undertaken by the Oxford Archaeological Unit in conjunction with the Council for British Archaeology, Oxford University and DEFRA. Nevertheless, major UK monuments remain by socio-economic necessity under the plough. A recent condition survey of Avebury World Heritage site in Berkshire, for instance, revealed that predominantly arable farmland cultivation accounts for about 46 per cent of the threats to the region's archaeological monuments (Lambrick 2004: 188, 190). Around half of the 1,000 known monuments in the Avebury and Stonehenge World Heritage Sites are still ploughed (Young *et al.* 2008: 36). Balancing proportionate protection with essential access to farmers and economic rationale is a complex real-world problem that is shared equally by fishermen.

The well-studied British situation is applicable across the wider world. Whereas the impacts on archaeological resources arising from construction and urban development are routinely assessed and mitigated today throughout Europe, the impacts of agriculture, forestry and related land use on monuments mainly lie outside imposed controls and are generally not assessed, licensed or subjected to any mitigation (Trow 2010a: 19–20). As a consequence, many countries like Norway experience high rates of damage and destruction to archaeological sites and monuments, where 'preservation *in situ* is frequently not possible, and "preservation by record" by means of controlled removal by excavation is required' (Smedstad 2010: 19).

This harsh yet logical conclusion has obvious relevance to attempts to control the seas (see Chapter 6).

Outside Europe, field ploughing associated with the planting, aeration and irrigation of olive orchards, vineyards and field crops is gradually erasing many sixth- to fifth-century BC mortuary mounds in the landscape of Bin Tepe near Sardis in Turkey. The most dramatic example is the complete destruction during ploughing of an olive orchard of three tumulus chamber tomb complexes (fortunately previously excavated and published in the 1960s by the Archaeological Exploration of Sardis).¹ Ploughing at Kissufim, east of Gaza, similarly ripped through a mosaic from a mid-sixth-century Byzantine church, one of the finest in Israel (Cohen 1980), and is a recognised post-depositional sampling issue in almost all countries from Australia to the obliteration of Aztec landscapes in Mexico.

Heritage management: all at sea

The economic obligation to keep the cycle of life rotating trumps the protection of the past from agricultural cultivation. If society is unable to prevent massive plough damage to archaeological landscapes, where the detection of ancient sites is comparatively uncomplicated, only the most eternal optimist could hold high hopes for the underwater realm. Marine archaeology is yet to have its Dyke Hills moment leading to the enactment of protective law as began in the English town of Dorchester in 1870. Little consensus exists about whether we face a problem requiring management, let alone agreement on what optimum strategies to implement. No legal, practical or proactive protocols have been instigated. How has this mentality caught us so unawares, when marine ecologists have been tackling the matter head on for over four decades and encrusted wonders have been emerging from the world's oceans for 250 years?

One explanation is that marine archaeology – born with the *Aqualung* in 1945 – is a late bloomer compared with land archaeology. A traditional emphasis on method and technology has left theory catching up with the mother discipline. Due to complexities of site detection, access and visibility, an out-of-sight and out-of-mind mentality has been allowed to prevail as a default position. Because mankind cannot readily observe or quantify the full extent of the underwater resource (unlike in ploughed fields), it does not enjoy the same level of esteem as sites on land. Desperately low funding and fewer practitioners are part and parcel of the dilemma, leading to a compressed profile. Israel's two marine archaeologists is a normal representation for the Mediterranean. For UK territorial seas, there is just one officer for approximately 20,150 square kilometres of seabed, compared with one officer per 482 square kilometres for land in the county of Surrey (Flatman 2007: 87). This disproportionate representation typifies the worldwide pattern (with the exception of Sicily), where discovery, documentation and protection owe a huge debt of gratitude to the time, energy and funds of avocational dive groups.

A major hurdle in addressing how to protect underwater heritage from bottom trawling is the unsystematic and random nature of regional shipwreck records: society cannot hope to save what it does not know exists. The creation of databases synthesising dive records, fishermen's snags and netted artefacts is a crucial first step that few countries have achieved. Some nations subjected to intense bottom trawling regimes have formulated regional maps. Italy's *Archeomar* Project was provided with €7.5 million by a law enacted in 2002 to develop a register of submerged heritage along the coasts of Calabria, Campania, Basilicata and Puglia. The project consulted over fifty databases, public and private archives, conducted offshore surveys across 230 square kilometres of seabed with side-scan and multibeam sonar, and undertook over sixty missions to depths of 600 metres

using a remotely operated vehicle and a mini submarine. In total, more than 779 sites were registered (Ministry of Heritage and Cultural Activity 2011).

Through its long tradition of diving, extremely good coverage exists for southern France (for 118 wrecks between Brégançon and Antibes, see Joncheray and Joncheray 2012). The restriction of Israel's underwater heritage along a short 188-kilometre coastline to a narrow near-shore belt approximately 200 metres wide and under 7 metres deep (Galili and Sharvit 1992: 270), coupled with a strong antiquities law, has enabled the position of its wrecks to be comprehensively mapped and managed. No country, however, specifically factors the impacts of fishing threats into regional surveys. Meanwhile, shipwreck maps for Southeast Asia and the Far East are largely non-existent. National registers that do exist focus on shallows and are virtually empty for deep seas within both territorial and adjoining international waters, where fishing fleets increasingly venture. Marine archaeology has only started to scratch the surface of the oceans' potential.

The question of significance adds a crucial layer of intricacy. Most countries do not exploit objective methods to assess value and create a hierarchy of sites for addressing optimum preservation, instead relying on intuitive decisions. Under the definition of the UNESCO Convention on the Protection of the Underwater Cultural Heritage, ratified countries are bound to protect all underwater cultural heritage over 100 years old, a somewhat arbitrary and meaningless catch-all definition. In some countries where national histories and statehood are relatively young, including Australia and South Africa, the rarity of medieval and earlier sites means that post-medieval and early modern wrecks assume an enhanced value, so that wrecks over fifty years old are required to be protected (e.g. New South Wales' internal waters under the Heritage Act 1977: Staniforth 2007: 28). English Heritage's analytical system of defining significance according to different sequences of value (evidential, historical, aesthetic,

communal and instrumental: Conservation Principles, Policies and Guidance 2008), recently extended to underwater heritage, is a complex but smart tool that minimises bias and could be simply streamlined for other countries.

Irrespective of the question of site significance, which ought to be prioritised in considerations of what to protect, the prevailing trend in world marine archaeological management is the idea of preservation *in situ*, heavily promoted through the UNESCO Convention on the Protection of the Underwater Cultural Heritage. Even though deep-sea surveys conducted in the Black Sea and off southwest Turkey exposed extensive trails of destruction in the form of crushed amphoras and scattered timbers, the archaeological team studying the regions favours *in situ* mitigation. An approach based on continuous annual monitoring and repeat photomosaics to document the frequency and intensity of damage has led to the conclusion (Brennan *et al.* 2012: 68) that, 'while shipwrecks in the Aegean Sea have been and continue to be threatened by modern fishing operations, the creation of protected areas and regions where bottom trawling is prohibited increases the chances that cultural sites will be preserved to the point that they can be found and properly documented'. The team's deductions are hard to square with their own additional conclusions that, 'It is essential to continue to conduct rapid comprehensive surveys of such threatened areas before these sites are damaged further, potentially beyond the point at which they can be detected' (Brennan *et al.* 2012: 69).

The situation is clearly more serious in the Black Sea, where heavy trawling is restricted to depths above 155 metres and the anoxic waters devoid of fish life. In this restricted zone of exploitation, 'Due to the extent of this damage, some of the more heavily impacted wooden wrecks can only be assessed on a rudimentary level with little to no diagnostic evidence of their origin or date.' Despite deploying a sensor package at 103 metres off Sinop in 2007 to try to assess

long-term environmental changes, the equipment had succumbed to a trawler by 2011, which ‘raises a question of how such long-term data sets can be collected while avoiding trawling’ (Brennan *et al.* 2013: 100).

While the precedent of conservation zones encouraged by European Union law is undoubtedly the future for marine habitats (see Chapter 6), there is no overnight solution for marine archaeology. In the interim period evidence continues to vanish, typified by the late fourth-century BC Ereğli E wreck in the Black Sea, which was so badly disturbed by trawlers between 2011 and 2012 that they ‘uncovered materials from beneath the sediment, including human bones. The bones had been preserved in the mud, but then had been ripped out by trawls ... When we returned this year the artifacts we had seen the year before were either further damaged or gone, including the bones that were completely missing, again due to trawling.’² Under such circumstances of rapid site destruction of major primary data, leaving wrecks *in situ* without selective sampling or excavation seems at best counter-intuitive, bending over backwards to accommodate UNESCO ideals, and at worst cultural suicide. The extensive structural damage to almost all wrecks in the Stellwagen Bank National Marine Sanctuary in the Gulf of Maine (Studds 2008: 126, 168) also seems to be at odds with the sanctuary’s legal mandate to protect its maritime heritage under numerous regulations from the Antiquities Act of 1906 to the Stellwagen Bank National Marine Sanctuary Regulations of 1992.

Appropriately for the earliest country historically documented as subjected to shipwreck impacts by the oyster dredges of Whitstable, the UK has examined a common-sense reactive approach to mitigating bottom fishing impacts. Drawing on the successfully established structure for reporting finds unexpectedly landed by aggregate dredge ships (Chapter 1), the Fishing Protocol for Reporting Archaeological Discoveries (FIPAD) was trialled in April 2012 as a

one-year pilot study on the Sussex Inshore Fisheries Conservation Area in southern England (Wessex Archaeology 2013). The project commissioned by English Heritage created a web-based protocol for the voluntary reporting of sites and artefacts of historic interest discovered by the fishing industry during its daily work. A key question was whether an established reporting mechanism would encourage fishermen to declare cultural heritage to enhance England's National Record of the Historic Environment.

The scheme was trialled along 145 kilometres of coast between 0 and 6 nautical miles offshore, where the UK has exclusive rights. The zone is fished by 400 small vessels, most less than 10 metres long, crewed by one to three people operating out of nine fishing ports. Despite an extensive promotional campaign involving sustained media coverage on television, radio, the printed press and Internet, supplemented by educational port visits from Wessex Archaeology staff, just two wreck sites were reported. A further forty artefacts were subsequently declared after the scheme's remit was expanded to report retrospectively material found since 1969. The finds ranged from a mammoth bone to a late medieval French granite statue of a deity, although the majority of material declared was twentieth century. The overall volume of reports was a disappointment. Based on the average thirty to forty finds reported per annum through the offshore aggregates industry and renewables industry protocols, around 200–300 finds were anticipated for the fishing protocol.

The low response was explained by fishermen's reticence to declare wrecks, obstructions, navigational hazards and fasteners logged in their navigational software that might lead to legal restrictions around archaeologically important sites. Economic possibilities inspired some fishermen to propose that a monetary incentive would have a substantial impact on the motivation to report. A final and important explanation for the low level of reporting was suggested to be the proportionately small number of new discoveries: the volume of

artefacts recovered in recent years had purportedly steadily declined, especially in areas subjected to repeat fishing (Wessex Archaeology 2013: 5, 17, 19).

As a regional test ground for mitigating bottom fishing in the UK and the wider world, the FIPAD Project has interesting implications. Declining numbers of finds corresponds with impressions of reduced discoveries of cannon snagged by Dutch trawlers in the North Sea (Nico Brinck, personal communication, 15 March 2011), for few new wrecks reported as far afield as Malaysia (Sten Sjostrand, personal communication, 13 January 2015) and extends to a decrease in the number of munitions caught in the Bornholm Second World War dumpsite in the southern Baltic Sea since 1992 (on average five to ten annually) (Missiaen *et al.* 2010). The substantial funding that would be required to kickstart a similarly structured scheme nationwide suggested to the FIPAD team that a number of rangers would be a far more effective monitoring mechanism (Wessex Archaeology 2013: 16). A major concern is the reality that fishing is trans-boundary. If fishermen are so protective of their hangs in shallows, how can authorities successfully encourage and manage the reporting of archaeological finds from 6 to 12 nautical miles off the UK, where numerous other countries have historical rights of access, let alone beyond 12 nautical miles, which permits common access to all European Union fishing vessels?

An important study commissioned by English Heritage in 2012 assessed former impacts in two offshore areas to examine the interaction between commercial fishing and the marine historic environment. The report determined that the key to successful management is the establishment of a strong working relationship between archaeologists, fishers, scientists and regulatory bodies by tackling mistrust and a lack of shared understanding. A need was identified to encourage fishermen to make their hang lists available, through either suitable incentives such as relatively modest investment or nil cost options that offered

non-monetary or indirect benefits to fishers (for example, by providing flexibility in the interpretation and application of fisheries management regulations or sharing detailed archaeologically derived data). English Heritage was advised to engage with Seafish, the Marine Management Organisation and industry representatives to prepare good practice guidelines on how damage to heritage assets can be avoided (Firth *et al.* 2013: 66, 76, 119, 120).

Summary

Just as the ploughing of fields during the last century wiped out large swathes of archaeological sites, bottom fishing towing intrusive gear can cause extreme damage. Society must accept that just as on land, future seascapes studded with underwater cultural heritage will look vastly different to today. Above the waves in the United Kingdom it took between 1870 and the 1970s for the scale of destruction to be seriously assessed. Must marine archaeology wait a similar number of decades before proactive protection options are implemented? Not necessarily. The lessons from ploughing impacts and, most closely, marine ecology offer opportunities to learn from accumulated experience and wisdom (Chapter 6).

The threat beneath the waves is far greater for the obvious reason that water covers 70 per cent of the Earth's surface. The invisibility of the resource strewn across such enormous areas remains a serious obstacle: we can only decide how to treat a wreck at risk once it is found; but by then it may be too late if a site has already been blitzed for decades. Until countries manage to identify, register and grade according to significance their underwater cultural heritage, dealing with all forms of risks from looting to fishing impacts will remain a reactive process, by which time a certain level of damage is unavoidable.

Even where well-formulated classifications exist, monitoring is a tall order. Whereas monuments on land can be readily spot checked seasonally at any time by the proverbial grey-suited man from the ministry wielding a clipboard, his underwater equivalent has to dodge bad weather and changes in sediment levels that can randomly cover and expose wreckage on a weekly basis, and strategically select which sites to assess and which to neglect. Better regional site maps are required, as well as recognition of what fishing impacts look like and their registration in databases. As the Archeomar initiative and surveys of southwest Turkey, the Black Sea and the Atlas Shipwreck Survey Project off the UK aptly demonstrate, the technology exists to ask the right questions of seascapes, even in deep waters. In many woefully resourced countries, including parts of Southeast Asia, realistically comprehensive surveys are pipedreams where management will remain at best a reactive forest-fire-fighting exercise.

To date, almost no theory comparable to mitigation preferences considered for ploughing on land has been proposed for the underwater realm. Greater analytical thinking is required – and swiftly. The limited options proposed include a preference for the *in situ* recording of wrecks endangered by bottom fishing and an attempt to monitor cultural catches by encouraging reporting. Due to economic pressures, just as preservation *in situ* has proven unworkable on land in Norway, it is a highly precarious catch-all strategy beneath the waves.

The greatest difference between agricultural cultivation and bottom fishing is that coins and sherds brought to the surface under the plough move little from their original contexts. Marine finds, by contrast, are typically displaced over great distances, often many kilometres. Numerous methods from fieldwalking to aerial photography and geophysics can readily identify a site vulnerable to ploughing, but chasing down the core of an impacted shipwreck – a needle in a haystack – can be hugely complex. Farmers happily

encourage regional archaeologists, metal detectorists and television programmes like 'Time Team' to unravel the secrets of their fields, but fishermen tend to be secretive about any shipwrecks they hit and associated finds because wrecks are crucial economic assets as artificial oases for teeming marine life. More fish means bigger catches and greater profits.

Fishermen guard their favoured fishing grounds and associated hangs warily. Although no skipper wishes to lose valuable nets or become snagged on a hull, some will walk a tightrope by risking steering as close to a wreck as possible to harvest fish aggregations. Some skippers deliberately trawl over a partly silted wreck despite the danger. Fishermen even risked towing directly across the Birch Point Explosive Dump in the Firth of Clyde for the sake of catch yields, where explosives were deposited between 1953 and 1989, scattering explosive waste up to 28 kilometres outside its centre (Ferrari 1994: 83, 121, 125). Along identical lines fishermen risk trawling through a dumpsite east of the island of Bornholm in the southern Baltic Sea, where over 32,000 tons of chemical warfare material was discarded after the Second World War. Despite the zone being publicised as 'anchoring and fishing not recommended', since 1960 over 720 finds of chemical munitions have been reported in fishing nets and the main dump has been strewn up to 50 kilometres away from the central boundary (Missiaen *et al.* 2010).

The case of the late seventeenth-century armed merchantman trading with West Africa, surveyed at a depth of 110 metres in the Western Approaches to England, reveals the vulnerability of historic wooden wrecks with low reliefs of under 50 centimetres over which trawlers will tow. The general consensus in the UK is that 'the stated ideal of conserving the integrity of archaeological deposits while avoiding significant disruption to fishing activity is unlikely to be achievable' (Ferrari 1994: 177). Interviews with fishermen off America's East Coast similarly determined that bottom gear tends to

be unaffected by small obstructions. Offshore netters expected to severely snag a net once every one to four years and to suffer complete net losses every five to ten years. Captains were also unaware of the existence of major wrecks: analysis of a second-generation offshore netter's list of 19,000 hangs with a confirmed shipwreck database found that the fishermen had missed sixteen large wrecks within 80 kilometres of their home port. Two-thirds of hangs proved to be unproblematic for large boats, while strong modern nets allowed fishing without incident across areas formerly identified as snags (Steinmetz 2010: 119, 129).

In seeking solutions tailored to underwater cultural heritage, the resource emerges as having different problems needing alternative solutions from terrestrial monuments and endangered marine habitats cocooned within no-take exclusion zones or marine reserves.

So where do we go from here in seeking sustainability?

Conclusion: Seeking Sustainability

Beneath our seas is strewn an untold wealth of knowledge – perhaps the greatest museum in the world. The vast potential to humanity is almost inconceivable. The pathways of our prehistoric ancestors from Africa to farmers may await discovery beneath the waves, so that ‘unless we go underwater whole areas of understanding about world prehistory will go by default’ (Bailey 2004: 9). The organic and metallic shipwrecked artefacts so well preserved underwater, but rarely encountered on land, enhance our appreciation of almost every civilisation that has inhabited the planet.

These seas are not the untouched paradise that early explorers romantically assumed. Lord Byron’s poetic assertion in *Childe Harold’s Pilgrimage* (1818) that ‘Man marks the earth with ruin – his control stops with the shore’ is no longer true. Pressures continue to soar through the demographic explosion of Earth’s population and hyper-urbanisation. Oil and gas pipelines bisect seas, wind farm turbines turn frenetically and, increasingly, fibre-optic communications cables encircle global seabeds (Kingsley 2011: 238–240). All of these industries affect underwater cultural heritage in different ways, but have one point in common: to one degree or another the threat level is recognised and controlled. Of all these industries the footprint of the fishing industry – specifically bottom fishing using trawl nets and scallop and oyster dredges – is heaviest, a conclusion validated by considering chronology, geographic scope, intensity, routing and technology.

Bottom fishing has exerted the longest anthropogenic pressure on the seas ever since oyster dredges struck a Roman wreck at Pudding

Pan Rock in southern England in the mid-eighteenth century. Catches rose steeply in British waters from 1889, when over twice the volume of bottom fish were caught compared with today, despite the technological discrepancy between the two periods and an earlier reliance on sail power. British catches peaked in 1938, when fleets landed over five times more fish than today (Roberts 2012: 39). The chiselling away of sunken heritage is a century-old phenomenon in many parts of the world. Most other impacts are comparatively young.

In terms of geographic scope, industrial fishing is truly global, penetrating almost every country with a coastline. Arguably no sealanes once traversed by ancient and historical merchantmen and warships remain untouched. The geographic net of physical disturbance to seabeds exceeds the footprint forged by the ploughing of arable lands. Fertile fishing zones are criss-crossed intensively time after time year round, not seasonally as in the ploughing of a field, continuously hammering heritage lying in a trawler's path. Whereas pipelines and wind farms follow pre-determined lines, which can be surveyed and mitigated when they run close to a shipwreck, the routes followed by bottom fishing are chaotic to archaeology. Fish shoals chased on echo sounders, sonar and catch monitor instrumentation follow no predictable path. Finally, the industry's traditional technologies are demonstrably intrusive, eroding marine habitats and shipwrecks with varying degrees of severity.

The root of the issue is economic and as such is unlikely to go away: society needs the commitment of hard-working fishing communities for seafood. As many experts have reiterated, however, the management problem is not economic. 'All things considered,' Sylvia Earle, National Geographic's Explorer-in-Residence has highlighted, 'the politics of commercial fishing – not the fishermen or the markets or the destructive gear – may be the largest problem facing the ocean today' (Sloan 2003: xv). There is no good strategic reason, though, for the world's sunken secrets to be abandoned to

purgatory. The trials and tribulations of ploughing on land and current marine ecological mitigation policies, plus methods extant in marine archaeology, can serve as templates to safeguard the deep.

How can parity of esteem with land sites be promoted and developed? The heritage community certainly needs to start thinking smarter and strategically, and eight core aims can be identified to foster change:

1. Acknowledging the reality of irreversible damage and the existence of a problem needing critical attention.
2. Assessing, quantifying and understanding the scale of the problem nationally.
3. Promoting the negative implications of uncontrolled bottom fishing on underwater cultural heritage.
4. Proposing management options and qualifying their likely effectiveness.
5. Achieving recognition of the issue among politicians, NGOs, heritage managers and the public.
6. Interfacing with the fishing community to improve understanding and reach consensus about balanced management approaches.
7. Identifying means of improving the evidence and research base to negotiate better outcomes for archaeological site management within national and international protocols and legal frameworks.
8. Seeking changes to legislative frameworks to enhance protection.

Society currently has not progressed beyond the first stage on this list. As the inescapable starting point, the fundamental truth must be acknowledged that irreversible damage has been inflicted on delicate underwater cultural heritage and, unchecked, will continue. Just as archaeologists have come to realise for ploughing on land that the future will hold a greatly modified rural environment, where the opportunity to locate and study well-preserved sites is rapidly declining (Yorston *et al.* 1990: 67–68), it is unavoidable not to reach the exact same conclusion for the impact of bottom fishing.

Sadly, the threat to shipwrecks is far more detrimental to marine environments because, it is essential to reiterate, given beneficial environmental conditions both fauna and flora can regenerate, whether seasonally or over decades or a century. Once a wooden historic shipwreck has been struck by fishing gear, the damage and erosion of knowledge is permanent. Some seas have witnessed in the space of a few generations the pandemic wiping of their archaeological hard drives, leaving behind a flat-lined legacy to future generations.

Just as metal detecting and ploughzone archaeology have unearthed unexpected primary data, we have no alternative but to seek positives in tackling fishing impacts. In a field where the task is hard enough financially and practically, the political posturing and antagonism between stakeholders holding divergent philosophies (commercial versus conservation) is destructive to what should be a mutual cause of saving the sunken past.

Making technology work

Trawling shows no signs of disappearing. United Nations' calls for a global ban in 2004 were blocked and in December 2013 the European Parliament's Fisheries Committee rejected a further petition to prohibit all trawling. Just localised bans on bottom fishing are in place in some locations, including for instance 500,000 square miles of Atlantic waters surrounding the Canary Islands, Madeira and the Azores, and across 630,000 square miles of deep-sea Mediterranean waters (Stiles *et al.* 2010: 8).

In a world where the seas are not closed *en masse* to fishing, changes in technology could contribute significantly to a sustainable future. Most technological innovations address purely ecological issues, which have no direct and little peripheral bearing on underwater cultural heritage. The invention of an advanced 'Gel Spinning

Technology' using extremely high-strength Dyneema SK60 'Super Fibre' for nets may allow a rope of 1 millimetre diameter to bear a load of up to 240 kilograms in Mexican shrimp fisheries, reducing chances of net losses (Heredia Quevedo 2001: 14), but for marine archaeological resources increased strength worryingly means greater potential to rip apart snagged wreckage.

Changes in fundamental beam functionality could dramatically reduce impacts. One potentially significant innovation for sunken sites is electric pulse trawling introduced by the Dutch in 1992. Pulse trawling was designed primarily to reduce fuel costs and improve catch efficiencies by towing lighter bottom gear. Trawl heads and tickler chains are replaced by an array of parallel electrodes, which send an electrical pulse around the net to shock and stun fish off the seabed and propel them into a net. The removal of chains reduces the environmental effects on marine habitats (Linnane *et al.* 2000: 19, 22). Dutch advocates argue that pulse gear has less contact with the seabed and benefits include more target species caught, less by-catch, less damage to the seabed, less damage to caught fish and thus higher prices at market, which justifies the £300,000 cost of trawl boat conversion. Early trials of electrofishing yielded promising results, reducing bottom contact by 75 per cent (Woolmer *et al.* 2011: 9).

The number of Dutch trawlers allowed to operate pulse trawls was increased in 2012 to 10 per cent of the fleet, while its use has expanded to a small number of British fishing vessels working in the North Sea.¹ With the Dutch fishing industry pushing hard for greater acceptance of the technology, and fishermen all over Europe attracted by lower fuel costs and better quality catch, pulse trawling could quickly escalate. The technology is still deemed highly controversial in some scientific circles because the technique may tangentially electrocute fish stocks. The evidence for the East China Sea, where pulse trawling was used extensively in the 1990s to catch shrimp, certainly raises questions of sustainability. By the year 2000, about 3,000 Chinese beam trawlers

were equipped with pulse trawling gear. Although shrimp catch rates increased, the damage inflicted on juvenile populations and other benthic species resulted in the technology being banned in 2001 across the East China Sea (Yu *et al.* 2007). Masses of dead Dover sole coming up in British trawlers' nets have already been attributed to the side-effects of pulse trawling. A study by the International Council for the Exploration of the Sea confirmed that cod close to the pulse trawl gear suffer from cracked vertebrae and internal haemorrhaging resulting in increased mortality. Additional research has been called for (Grieve *et al.* 2014: 71). If a sustainable balance can be found, expansion of this technology would be good news for underwater cultural heritage through reduced seabed contact purely from the perspective of archaeological self-interest.

Enhanced protection can also extend to otter boards designed with improved hydrodynamic characteristics to reduce drag, turbulence and sediment disturbance. Some new designs have little or no contact with the seafloor. Prototype CP1 Batwing otter boards produce half the drag and reduce the accumulation of benthic material in the net by up to 90 per cent compared with traditional prawn trawl otter boards. Changing from rigid to spring-loaded scallop dredge teeth softens impacts with seabeds. Meanwhile, the Hydrodredge invented by the Massachusetts Institute of Technology for the New England fishery for giant scallops uses cups to deflect water into a downward jet to create large-scale vortices to lift scallops into the water column for capture. The technology has the potential to radically reduce the damaging effects of dredges (Grieve *et al.* 2014: 77–78, 81).

Economic war chests and public outreach

Proactive sustainable management requires not only creative thinking, but also access to monetary war chests and complex negotiations to

reach the ears of politicians. Marine archaeology is infamously badly resourced and most countries' underwater cultural heritage is an underperforming asset, which in terms of perceived value and significance is rooted to the bottom of marine science's food chain. Hard-nosed governments ultimately gauge value in economic rather than cultural terms. Pure cost-benefit analyses evaluating why protective policies should be invested in to protect wrecks at risk are unlikely to be sympathetically received.

An irrational disconnect differentiates marine biology from marine archaeology. Campaigners and politicians seemingly have greater empathy for the plight of fish and seagrass than wrecks and sunken settlements. Is this because society's cerebral default position equates the sunken past to SCUBA diving, treasure, escapism and entertainment? Is the sunken past more of a luxury than a resource (Giesecke 1987: 227), a spectacle to be gaped at in museums rather than appreciated as helping define who we are, where we come from and holding untapped knowledge about past human behaviour? What are the political, economic and cultural motivations for governments to tackle expensive mitigation?

Museums could be expected to be the most ardent supporters of saving shipwrecks to cycle discoveries back into new exhibits and education. However, very few actively sponsor and promote underwater fieldwork. The vast majority of shipwrecked heritage and prehistoric bones surfacing in fishing nets are of major importance in writing histories of migration, trade routes and ancient economies, but seem to be of little interest to influential national museums. Maritime museums that house the *Mary Rose*, *Vasa* and several ancient wrecks in Bodrum are often argued to prove the financial sustainability of shipwreck excavations (Throckmorton 1990). These centres of excellence are a minority, whose success is based on exceptional collections, not humdrum assemblages. In general, marine cultural heritage cannot be funded in the short or long term by visitor

income, and only one flagship project is likely to be attractive in any individual region (Dobbs 2007: 76–77).

National institutions are mainly unreceptive to humble wreck collections, which other than statues and high-value artefacts hold little perceived excitement. The 250 objects from the sea on display at the British Museum, among a collection of 80,000 objects (0.3%), are almost exclusively Moroccan gold coins and jewellery excavated from the seventeenth-century Salcombe Cannon Site. The same museum's King's Library displays in its re-configured Cabinets of Curiosity a few pots bought by antiquarians from the Roman wreck off Pudding Pan Sands. Meanwhile, almost no shipwrecked artefacts – if any – are on display at the National Maritime Museum in Greenwich. Persuading major museums to sponsor national surveys because they can benefit culturally has little attraction as a track record.

If war chests are inaccessible to fund extensive underwater surveys geared to mapping regional shipwreck records, and thus identify which sites are at risk from bottom fishing and other threats needing monitoring, reactive reporting and promotional public outreach can be comparatively low-cost/high-yield alternatives. A line in the sand could be drawn by imposing a Wreck Amnesty for Fishermen (WAF) to declare without legal recourse inadvertently snagged artefacts, along the lines of those initiated more generally for divers in Australia in 1993, the UK in 2001 and Bermuda in 2003. The Australian initiative resulted in 20,000 new artefacts being declared (Rodrigues 2009) and the UK amnesty over 30,000 objects and a further 4,000 reports (Hampshire & Wight Trust for Maritime Archaeology 2009: 15).

Economic realities make it highly dubious whether the fishing industry would be receptive to a wreck amnesty because revealing hangs has a direct bearing on professional livelihoods. Both the East Coast of America study of fishing industry attitudes (Steinmetz 2010) and the UK's Fishing Protocol for Reporting Archaeological

Discoveries confirmed the relative secrecy with which fishermen guard the positions of their hangs, often associated with lucrative fishing grounds. Whereas staff working in aggregate dredging have been persuaded to voluntarily declare finds, trawlers that recover cannon in nets from the Far East to the North Sea almost never report material. Cannon often re-surface in antique shops from London to America. Fishermen advised the UK FIPAD scheme that economic incentives would mean a greater chance of snagged finds being reported. High monetary rewards given by the Greek State have motivated fishermen to keep an eye out for new discoveries (Katerina Dellaporta, personal communication, 12 March 2015).

To inspire industry change, amnesty and reporting initiatives have to be preceded by public outreach to explain cultural values, such as Israel's low-cost strategy of marine finds depicted on national stamps and the display of posters illustrating common finds (anchors, amphoras, ingots) in all the country's dive clubs (Galili and Weishoff 2010). Leaflets replicating a marine archaeological equivalent of English Heritage's 'Ripping Up History' plough damage campaign could be equally powerful (Trow 2010b: 131). Pursuing the incentivising approach to declaring heritage, the replication of the UK's Portable Antiquities Scheme to global underwater environments would create a balance with land. Although this financial incentive protocol has revolutionised the reporting of high-value finds unearthed by metal detectorists, produced substantial research papers and inspired the public through media coverage, there has been no debate about the negative and positive effects of its application beneath the waves. The scheme's database currently holds nearly 700,000 objects and about 300,000 images, raw primary data that since 1997 has generated 449 research projects from high school projects to PhD research and major publications covering all periods from the Bronze Age to the post-medieval world.²

Unlike the case for land, where archaeologists can converge on archaeological sites after a metal detectorist declares the discovery of

a hoard, the coordinates where an object was snagged in a net before being dragged for miles and recovered can almost never be provided. A PAS-style scheme underwater nevertheless can only improve the current very low evidentiary benchmark. Currently, few other financial incentives have been considered to encourage fishermen to report finds, although some studies suggest such an approach would be well received. A UK report for English Heritage reiterated that for relatively modest investment or non-monetary benefits core data might be shared, including wreck locations or seabed maps (Firth *et al.* 2013: 76, 120). Another possible flexible nil cost option for deep-sea environments would be to exchange the coordinates of non-archaeologically significant shipwrecks where fishermen can work for information about historically valuable sites. The former far outstrip the latter and would enhance fishermen's chances of increased yields.

A more obvious immediate economic route would be to apply the equivalent of the 'polluter pays' principle that prevails in most countries through rescue archaeology. Just as aggregate dredging and offshore gas and oil industries are charged with mitigating their impact on shipwrecks and submerged prehistoric settlements at risk, the geographically far wider footprint of the fishing industry could be taxed at the national level in the same way – the most just and effective approach. At present, there is no appetite to consider a measure that would require radical, newly integrated legislation across disparate political regimes and would impose yet another layer of cost and complexity on the beleaguered fishing industry.

Environmental solutions

Practical mitigation options focused on individual sites vary widely from non-disturbance to intrusive measures. At the most

benign end of the spectrum, is it realistic to extend the UNESCO Convention on the Protection of the Underwater Cultural Heritage's preference for preservation *in situ* to shipwrecks identified as being at risk from bottom fishing? Certainly, geofencing, exclusion and buffer zones, and marine reserves are increasingly favoured as the optimum solution for conserving unique marine habitats and saving collapsing fish stocks. For Callum Roberts (2007: 376), reserves 'have to be placed centre stage as a fundamental underpinning for everything we do in the oceans. Reserves are a first resort, not a final resort when all else fails.' To lift overall stocks to sustainable levels will require roughly 30 per cent of the world's oceans to be blanketed with mosaics of marine reserves at a cost of £7.0 to £8.2 billion a year. Initial one-time set-up costs are estimated at about five times this amount. These sums seem colossal but, as Roberts points out, they are far less than the £18.2 billion Europeans and Americans collectively spend on ice cream each year (Roberts 2007: 378, 380, 383–384). Annual costs of global subsidies for unsustainable fishing currently exceed a colossal \$34 billion (Earle 2009: 237).

Figures compiled by the UN Food and Agriculture Organization show that two-thirds of the species fished since the 1950s have experienced collapse, and that the rate is accelerating because politicians have handed the fishing industry on average a third larger catch quotas over the last twenty-five years than scientists recommend as safe (Roberts 2012: 46, 261, 265, 277). Unlike the case for underwater cultural heritage, setting large tracts of the seas off limits makes sound financial sense: the World Bank report, *The Sunken Billions*, highlights the madness of overfishing by calculating that the major world fish stocks would produce 40 per cent more if fished less (Arnasan *et al.* 2009: xvii).

Justifying how ancient and historic shipwrecks might fit into a marine reserve model is a tough sell. With its serious economic

message and powerful implications for preserving biodiversity, marine ecologists are still fighting an uphill battle to force governments to act. Today, just three-fifths of 1 per cent of the world's seas are protected (Roberts 2007: 380), a far cry from the necessary 30 per cent proposed. Unlike the fishing industry, in the majority of cases preserving a wreck cannot be argued to make sound, let alone essential, economic sense. The rationale underlying exclusion zones and marine reserves permits the regeneration of fish populations and marine habitats. It is not an open-ended initiative. The ringfencing of a shipwreck, by contrast, would need to be a permanent measure, financially and administratively.

Geographical size plays an important role when considering the suitability of wrecks for marine reserves, which are typically extensive stretches of unique habitats, such as the 640,000 square kilometre Chagos Marine Reserve closed to trawling. The area of an individual wreck mound that might be at risk from fishing damage is unlikely to exceed 50×25 metres and most often half that size. Designating sprawling marine parks as off limits to trawling around a drop in the ocean will be hard to justify other than where sites fortuitously lie within the confines of reserves developed for wider ecological purposes.

Because of economic and logistical complexities, avoidance is currently the preferred method for mitigating the potential impacts to underwater heritage from aggregate dredging to oil and gas pipeline cutting (Firth 2013: 55). What forms of exclusion zone are realistic for wreck sites? The simplest and most cost-effective *in situ* tool is deploying a protective buoy adjacent to a site to warn off trawlers. Even when accompanied by educational and stakeholder outreach and threats of fines, buoys are no cast-iron guarantee of success, as impacts on several UK Protected Wrecks, the *Mary Rose* and sites off Indonesia demonstrate. Ten wrecks have been discovered in the UK through net snags and designated under the Protection

of Wrecks Act (Firth *et al.* 2013: 90), and at least five more have been subsequently disturbed by fishing gear (the Bronze Age Langdon Bay wreck; early sixteenth-century Studland Bay wreck; mid-sixteenth-century merchant vessel, Yarmouth Roads; *Hazardous* warship, sunk 1706, Bracklesham Bay, West Sussex; *Resurgam* submarine, 1880, Denbighshire, North Wales). Who will pay to enforce the continuous monitoring of endangered sites is hard to imagine. Preservation *in situ* beyond the sight of land that requires extensive personnel, research vessels and appropriately tooled ROVs and AUVs for monitoring is an even tougher prospect for which costs quickly spiral.

In seeking localised alternatives, the rarity of well-preserved cargoes undisturbed by diver-looters above depths of 60 metres off Croatia has led to eight endangered Roman amphora wrecks being enclosed since 1996 in iron cages at a cost of €63,000 to €94,000 per site (Radić Rossi 2014: 47, 58). These underwater zoo-museums are intended to protect against professional looters and allow divers to safely visit and enjoy Croatia's sunken past. Sicily enjoys one of the world's strongest resourced marine archaeological agencies, the governmental Soprintendenza del Mare, with around sixty permanent staff and exclusive control over underwater cultural heritage around Sicily up to 24 miles offshore. The Soprintendenza has prohibited near-shore trawling across major wrecks in collaboration with the Polizia di Stato, Guardia di Finanza, Carabinieri and Guardia Costiera, but enforcement is sometimes difficult. Total control is considered impossible and many cases of illegal fishing and site damage have been registered. Sicilian authorities have to deal with the immediate threat of heavy illegal immigration by sea, which is the priority for patrolling activities (Sebastiano Tusa, personal communication, 23 January 2015).

The Soprintendenza del Mare favours two means of optimum mitigation: the agency is planning to place huge concrete blocks

around wrecks of major importance to impede illegal trawler net dragging (Sebastiano Tusa, personal communication, 23 January 2015), a system long used in marine ecology around Cape Trafalgar off southwest Spain (Ramos-Esplá *et al.* 2000; Muñoz-Pérez *et al.* 2000) and to protect seahorse breeding grounds off Cambodia.³ Sicily has also pioneered video control monitoring at sites such as the Cala Gadir Punic wreck since 2002 and the Cala Minnola Roman ship. The system affords complete visual control of the adjacent coast and underwater environment and to date has successfully prevented all bottom fishing intrusion. An ultrasound pulse system recognises any possible infringement. An alarm signal, including the precise location of intrusion and an image of the site, is automatically sent to the police, who can decide on the need for intervention (Selvaggio *et al.* 2009: 418). The video-based Sistema Integrato per la Tutela dell'Archeologia Subacquea is considered the best means of ensuring full control of illegal activities because everything is video-registered and fishermen know that any infringement is easily recognised and punishable. Set-up costs for a site in 30 metres depth are around €150,000 for the equipment, €40 per metre for cable from shore to site and some €15,000 for yearly maintenance (Sebastiano Tusa, personal communications, 23 and 25 January 2015).

Where bottom fishing over shipwrecks continues unabated after a site has been declared an exclusion zone and publicised as such, an extreme tool of access prevention could be installing an Anti-Trawling Device. The Eco-Coral Corporation's tripwire system prevents the destruction of coral reefs, seagrass beds and the decimation of fish stocks where the prevention of illegal and disastrous activity is difficult due to a lack of resources. The device is a steel structure anchored to the seabed and equipped with two sets of sixteen revolving knives (unit cost \$18,295). When snagged by a trawl net, the knives cut the nets and release the fish to ensure that illegal trawlers cannot impede reef restoration processes. An

extension of this extreme solution to shipwreck protection could be extremely effective.⁴

Record or rot?

A fundamental weakness of the *in situ* preservation option is its limited contribution to the sum of human knowledge. Surveying the surface features of a site in an ever-decreasing state of preservation minimises chances to reconstruct domestic assemblages, ship and crew origins, cargo size, ship construction methods and daily life at sea. The historical particularism model, which emphasises the diverse and unique nature of a site as an expression of cultures comprising countless individual traits (cf. Bass 1983: 103), has for decades been a global tradition that has justified widespread excavation projects and recoveries. Lest we forget, large-scale excavation is the cornerstone of archaeological research and reconstruction for scientific and public benefits alike. Because wrecks are fine-grained assemblages in which artefacts and ship construction details can be tightly dated, they are crucial sources for developing robust artefact chronologies, multi-thematic interpretations and, ultimately, the writing of long-term history. As George Bass has argued (cf. Bass 2011: 10), 'A shipwreck, being a coherent whole, is more like just one burial. It is hard to imagine an archaeologist excavating only part of a skeleton and leaving the rest ... Sampling wrecks can lead only to historical inaccuracies. The debate should be closed.' In selecting mitigation options, society needs to decide whether pure protection or harvesting knowledge should take precedence.

Somewhat perversely, excavation is perceived as sacrilege in the age of the UNESCO Convention. During the first decade of its existence, European academics and heritage managers presented Rule 1 of the Convention, focused on preservation *in situ*, as a Parisian

preference. This regulation has become a powerfully abused political stick despite UNESCO clarifying that *in situ* is a first option for consideration, not the only consideration (Maarleveld *et al.* 2013: 25–26). *In situ* preservation has to be implemented for the right reasons, not as benign neglect to excuse bankrupt marine archaeological regimes or to blindly follow a policy proposed by lawyers in Paris – for a case in point, see Peacock (2009) for the wilful erosion of the warship *Stirling Castle*, 1703, on the Goodwin Sands. Just as the oceans are part of the public trust, held for present and future populations for purposes of commerce, navigation and fishing (Sloan 2003: xvi), underwater cultural heritage is imbued with generational trust. In some cases, excavation – removing heritage at risk from harm's way – will be the only sustainable form of protecting finite and non-renewable trawled resources because archaeological remains do not breed and lack the propensity for self-generation (Carman 2004: 256). Where preservation *in situ* is a Disneyesque fantasy for fishing-impacted shipwrecks, governments must be held responsible for securing funds to record and recover the most significant sites at risk.

When confronted by the figure of three million shipwrecks worldwide, this aspiration appears not just daunting but crippling. The number of sites actually requiring attention, however, is a minimal percentage of the global total. By way of example, of 37,000 shipwrecks historically documented as having occurred in English waters throughout history, of which 6,000 formed actual wrecks, just 47 (0.8%) are considered sufficiently significant to warrant designation under the Protection of Wrecks Act 1973 (Cant 2013: vii, 235, 240). Odyssey Marine Exploration's deep-sea survey of the Western Approaches and western English Channel identified over 270 shipwrecks in international waters dating from c. 1640 onwards, of which arguably just five (1.8%) are of sufficient archaeological importance to warrant intervention. The worldwide number of shipwrecks requiring intrusive attention

from bottom fishing appears far more manageable by applying the average figure of 0.8–1.8 per cent to national totals.

Towards a hyper-realistic future

No magic bullet can mitigate with one shot the effects of bottom fishing. Social, economic, political and cultural customs and pressures differ so widely from country to country that inflexible cherry-picked single solutions are a fool's paradise. The synergistic approaches implemented on visible land surfaces are a pipedream for the invisible seabed. As long as the issue remains a low political priority, practical mitigation options will have no alternative but to be approached regionally, reactively and on a site-by-site basis.

Risk levels differ hugely from stable to critical. The Western Approaches, western English Channel and North Sea have been heavily blitzed for over a century. The North Adriatic has been devastated. The waters of Sicily and southern Turkey remain a hot zone. The small band of intensively trawled seabed in the Black Sea is an acute concern. All manner of finds from Palaeolithic axe heads to Second World War airplane propellers have been netted across European waters. Most major porcelain cargoes off Malaysia, Indonesia and Thailand have been obliterated and their wooden hulls pulled apart. Many ships reflecting the history of early American seafaring and seventeenth- to nineteenth-century Spanish colonial trade off Florida, Louisiana, Texas and in the Gulf of Mexico have been heavily impacted. In these red risk waters, assessing what must be saved and what has to be abandoned to chance survival due to limited resources requires an understanding of the character and scale of the resource, its archaeological and cultural value, loss levels, what is most vulnerable and where the most serious risks lie – a hard task that calls for hyper-realistic brave decisions.

Even where sites of major importance are identified, vast slices of the world's sunken history are almost impossible to police. Customs officers are preoccupied combatting immediate pressures, such as drug running, tobacco contraband shipments, illegal immigration and terrorism. The very low economic benefits associated with ancient and historic wrecks make securing funds for the equivalent of Sea Shepherd's work to confront illegal fishing with rapid response vessels highly improbable.⁵ Indonesia's extreme strategy of blowing up trawlers caught illegally fishing within its waters would also be a dubious counter-measure for shipwreck trawling.

Just as marine ecology recognises and defines the most endangered species as Essential Fish Habitats (physical or biological features essential to the conservation of a species' survival or recovery), a comparable concept that may be termed Marine Archaeological Critical Resource (MACR) must be acknowledged and understood across the board – from divers to governments – to enhance preservation opportunities. Promoting a Red List of wrecks endangered by bottom fishing, for which mitigation is a crucial priority, would be a strong first step in imposing global awareness of the Marine Archaeological Critical Resource.

Meanwhile, the rhythms of the global fishing industry confuse assessments of present and future risk levels and optimum protective methods. Impact severities are conditioned by fishing intensity, and the evidence from the North Sea, North Adriatic and Malaysia seems to signify that impact scales are dipping as sites have either been obliterated or reach a state of equilibrium with the surrounding environment as past mechanical damage levels out. Three-quarters of the world's fish stocks are being harvested faster than they can reproduce, 80 per cent are already fully exploited or in decline, and 90 per cent of all large predatory fish – tuna, sharks, swordfish, cod and halibut – are gone. Some scientists predict that world food fisheries could collapse entirely by 2050 if current trends continue

(Worm *et al.* 2006).⁶ An end of the line in which the peak curve of damage inflicted on shipwrecks may have spiked would be a warped saving grace. While the offshore fishing curve dips, the future of aquaculture – a non-intrusive threat to underwater cultural heritage – looks bright as it continues to capture an increasing share of markets. In 2010, aquaculture accounted for 60 million tonnes with a \$119 billion farmgate value from a total of 148.5 million tonnes of global captures (United Nations 2012: 3, 9).

Arguing that the threat of bottom fishing to marine archaeological resources will correspondingly drop off as the industry's catch levels decline would be a serious error in judgement. No excuse or culture of denial that prevents the scale of former damage being qualified and future risks being predicted should be condoned. Abundant near-shore archaeological sites have undeniably reached the point of no return in terms of optimum reconstruction potential, as bottom trawling flattens maritime landscapes such as parts of Greece into the marine equivalent of 'an asphalt highway' (Katerina Dellaporta, personal communication, 12 March 2015), but what about the endless flow of ships that followed deep-sea shipping lanes throughout history?

Today, fishing trawlers travel increasingly further offshore in search of stocks or by necessity: countries like Malaysia have banned the activity within 30 nautical miles of shore (Nuruddin and Isa 2013). Around 40 per cent of the world's trawling grounds lie in waters deeper than 200 metres,⁷ and commercial trawlers crisscross the world's seas to depths of 2,000 metres (Roberts 2007: 309). A trend towards trawling greater distances offshore and deeper means that formerly untouched wrecks will start to be subjected to the same damage that has struck the shallows. As if keeping abreast of heritage impacts is not hard enough in designated regional waters where boat movements can be monitored, the waters far beyond the sight of land are highly susceptible to illegal fishing, a crisis that annually turns

over 10–26 million tonnes of fish worth up to \$23.5 billion a year. The high seas – the global commons – cover 45 per cent of the planet, but patchy regulations, scant enforcement and the vastness of the ocean make the effective policing of these areas extremely difficult.⁸

Ensuring that society learns from past patterns of bottom fishing damage is vital to ensure that Marine Archaeological Critical Resource collapse can be minimised in newly fished deep-sea zones. A crate of Enfield muskets made in the 1850s–1860s, new arms being shipped from the Tower of London for either regular British troops in Canada or the new Canadian militia, fished up in 2011 some 320 kilometres off Newfoundland,⁹ warns that extremely well-preserved deep-sea wrecks are no longer untouchable (Fig. 20).

Worryingly, it is precisely this class of deep-sea wreck that holds the best chances for optimum preservation and study. Where this maroons shipwrecks of major scientific value found beyond territorial waters not subject to national legislation remains a labyrinthine unresolved legal loophole. Despite claiming control over international waters, the UNESCO Convention provides no realistic proposals for such mitigation – only that ratified countries are bound to protect



Fig. 20 A crate of Enfield muskets made in the 1850s or 1860s, trawled up 320 kilometres off Newfoundland. Photo: courtesy Stephen Hull, Provincial Archaeology Office, Government of Newfoundland and Labrador.

deep-sea underwater cultural heritage. At present, this promises the impossible.

Whether large-scale bottom fishing continues unabated or ceases entirely, marine archaeology finds itself wandering confused around a moral maze. If fishing continues at current levels, steps will need to be taken towards sustainable mitigation. If it declines, the discipline will be left with severe wounds for which raising funds to record and understand the scale of former impacts may be a hard sell. The memory of these wrecks will simply wash away. Whatever the fate of the deep, with so little perceived commercial value, underwater cultural heritage is always likely to be judged a political irritant. Shipwrecks and impacted prehistoric sites will remain rooted to the bottom of the marine-based food chain. Saving and protecting a minor sample of the most significant history has to remain the realistic priority.

As fish stocks plummet and fishermen are forced to travel further and deeper to feed the planet, it is crucial that the lessons learned from marine archaeology's greatest threat are processed and applied. Sigmund Freud taught that to understand the adult, you must study that person as a child. Inside the psychology of archaeology, if we want to understand who we are and where we came from, we must study the infancy of mankind. The archaeological footprints at the bottom of the world's oceans are small and finite, yet historically precious. If we allow bottom fishing to devastate the most important narratives, turning the seas into a series of dead zones, we will have failed as custodians of the public trust by consciously erasing the hard drives of history. In this nightmare legacy, we will have nobody to blame but ourselves.

Notes

Chapter 1

- 1 Available online: <http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/protection/heritage-in-danger/> (accessed 19 November 2014).

Chapter 3

- 1 *European Trawlers are Destroying the Oceans* (Oceana): 35. Available online: http://oceana.org/sites/default/files/reports/european_trawlers_destroying_oceans.pdf (accessed 21 March 2015).

Chapter 4

- 1 Barnette, M.C., 'Lost at Sea: A Treatise on the Management and Ownership of Shipwrecks and Shipwreck Artifacts'. Available online: <http://uwex.us/lostatsea.htm> (accessed 6 December 2014).
- 2 'Fishermen Find Iron Cannon', *MACHU News* (July 2009). Available online: <http://www.machuproject.eu/news/news-45.htm> (accessed 30 May 2012).
- 3 Available online: www.nauticalarchaeologysociety.org/projects/holland5.php (accessed 25 March 2012).

Chapter 5

- 1 Available online: <http://www.bu.edu/clas/activities/tumuli/tumulus-exploration> (accessed 20 March 2015).
- 2 Bucci, A. (2012), 'Deep Sea Trawling Devastates Shipwrecks of "Alien Deep"', *National Geographic News*, September. Available online: <http://voices.nationalgeographic.com/2012/09/16/deep-sea-trawling-affecting-shipwrecks-of-alien-deep> (accessed 21 March 2015).

Chapter 6

- 1 Available online: <http://britishseafishing.co.uk/pulse-trawling> (accessed 21 March 2015).
- 2 Available online: <https://finds.org.uk/research> (accessed 21 March 2015).
- 3 Available online: <http://www.projects-abroad.org/volunteer-projects/conservation-and-environment/volunteer-cambodia/monthly-updates/?content=2012/june> (accessed 13 March 2015).
- 4 Available online: <http://www.artificialcoral.org/atd.html> (accessed 21 March 2015).
- 5 Available online: <http://www.seashepherd.org/news-and-media/2015/01/26/sea-shepherd-receives-83-million-euros-from-the-dutch-postcode-lottery-1664> (accessed 12 March 2015).
- 6 Available online: <http://saveourseas.com/threats/overfishing#1> (accessed 21 March 2015).
- 7 Available online: <http://saveourseas.com/threats/overfishing#1> (accessed 21 March 2015).
- 8 *Ending Illegal Fishing: Developing a Global Monitoring System to Combat Illegal, Unreported and Unregulated (IUU) Fishing*. Didcot: The Pew Charitable Trusts. Available online: <https://sa.catapult.org.uk/documents/10625/53165/Case+Study+-+IUU+-+July+2014Final.pdf/fd32b1e8-f441-4cf1-a1b6-95764300b142> (accessed 21 March 2015).
- 9 Available online: <https://nlarchaeology.wordpress.com/2013/02/01/gifts-from-the-sea> (accessed 21 March 2015).

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